

Video Quality Measurement PC User's Manual

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VIDEO QUALITY MEASUREMENT USER'S MANUAL

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The purpose of this handbook is to provide a user's manual for the video quality measurement (VQM) PC tool. This VQM software tool performs user-friendly interactive processing of video files. Program VQM runs under the WINDOWS® operating system and provides two methods for making video quality measurements. In the first method, the user must have original (i.e., reference) and processed (i.e., impaired) video clips stored on disk. In the second method, the user must have a set of original video clips stored on disk. Here the VQM tool can be used to construct a test video sequence (TVS) from this set of original clips, play the constructed original TVS through a video system under test, capture the processed TVS output from the video system, and parse the clips in the TVS for subsequent video quality analyses.

Program VQM compares the video sequence that has been processed by the video system under test to the original video sequence through two main steps. First, program VQM calibrates the processed video sequence to remove systematic differences between the original and processed, such as spatial and temporal shifts. Second, program VQM estimates and reports the perceived quality of the processed video using one of five video quality models. Quality estimates are reported on a default scale of zero to one, where zero means that no impairment is visible and one means that the video clip has reached the maximum impairment level.

The VQM PC tool is written in such a manner that it may be easily updated to incorporate future improvements in video calibration and quality analysis. Users are encouraged to email their suggestions for improving the VQM PC tool to vqm@its.bldrdoc.gov.

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1. VQM SOFTWARE OVERVIEW

1.1 VQM Software Objective

The VQM Software provides a means of objectively and repeatedly evaluating video quality. The software compares an original video clip and a processed video clip and reports a Video Quality Metric (VQM) that correlates to the perception of a normal end user. Figure 1 illustrates a high level snapshot of the process. Processed in this context refers to a previously undistorted video clip (original) that has been sent through a system under test (i.e., a codec, transmission medium such as wireless or internet, etc.) and saved to disk. The system under test that the video clip is applied to is referred to in the video quality community, as well as in this document as a Hypothetical Reference Circuit (HRC).

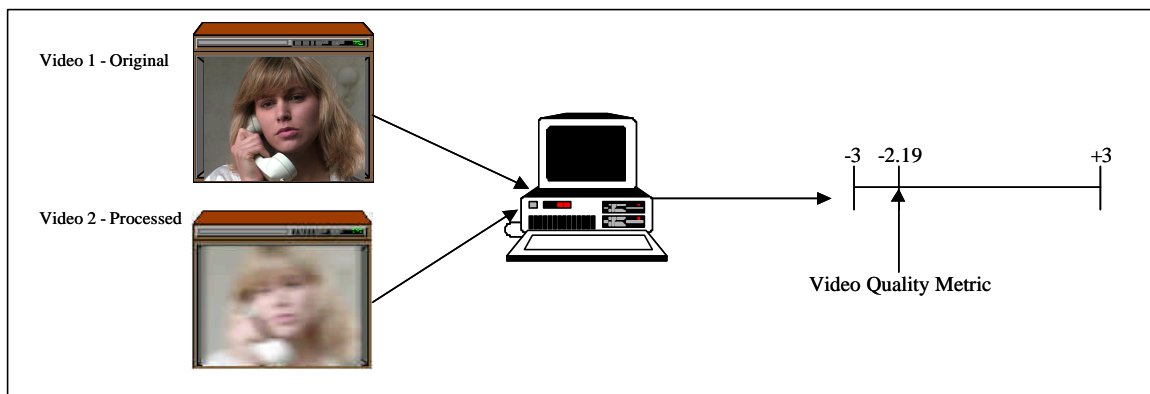


Figure 1. High level overview of VQM Software.

The VQM Software offers two means for measuring video quality; the first method assumes that the user has both original and processed video clips saved to disk and the second method assumes the user has only original video clip(s) saved to disk and that the user will be applying the original video clips to an HRC as part of the evaluation process.

1.1.1 Original and Processed Video Clips

In cases when the user has both original and processed video clips on disk, the user simply creates a library, calibrates the two video clips, and then measures the video quality of the processed video clip(s) relative to the original video clip(s). Figure 2 illustrates the process for the first method.

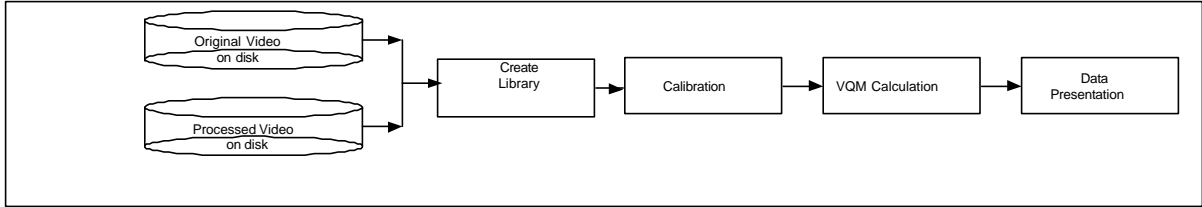


Figure 2. VQM software flow using both original and processed clips.

1.1.2 Original Video Clips Only

The second method assumes the user has only original video clip(s) saved to disk and that the user will be applying the original video clips to an HRC as part of the evaluation process. This second method is useful in applications where video capture is required (graphics chipset evaluation, DVD playback, CE device quality, and other applications when rendering quality is important). Figure 3 illustrates the process for the second method.

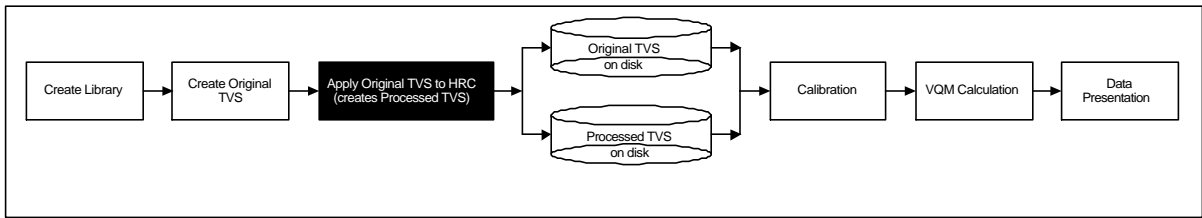


Figure 3. VQM software flow using original clips and TVS.

Note the methods in Section 1.1.1 and Section 1.1.2 have four primary components in common including 1) Library Creation, 2) Calibration, 3) VQM Calculation, and 4) Presentation.

In this second method, the user enters the original video clips into a library and then creates a Test Video Sequence (TVS). Figure 4 shows the relationship between the clip, library, and TVS.

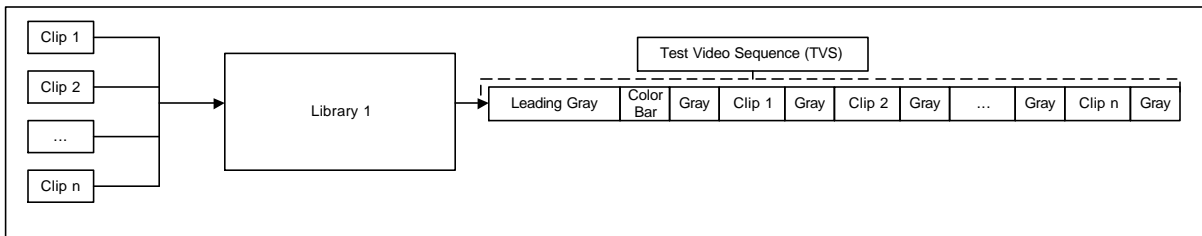


Figure 4. VQM software flow for creating a TVS.

The user then takes the newly created original TVS, applies it to the HRC, and then saves the newly acquired processed TVS to disk as illustrated in Figure 5.

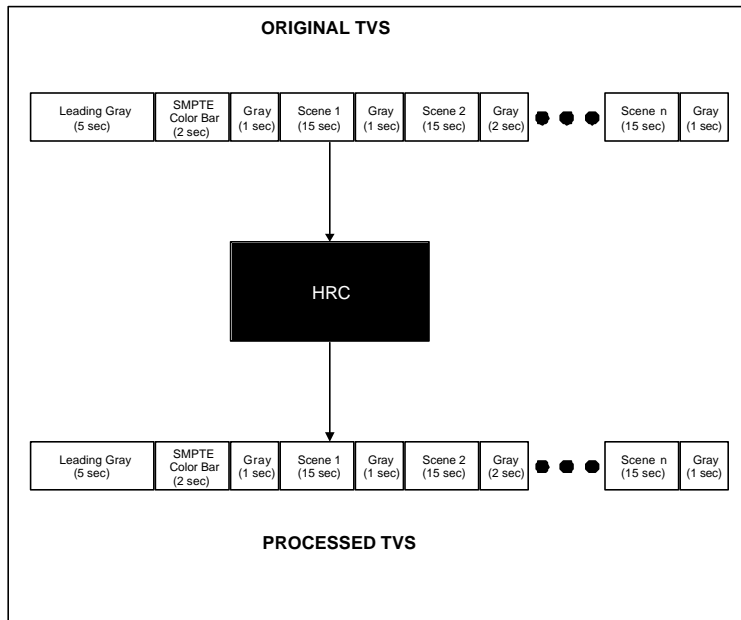


Figure 5. Creation of processed TVS from original TVS and an HRC.

The software flow is based on the library contents; if only original clips exist in the library then the “No” flow in Figure 6 is followed. If the library contents contain both original and processed video, then the “Yes” flow is followed. Section 2.3.2 describes the method for adding clips to a library.

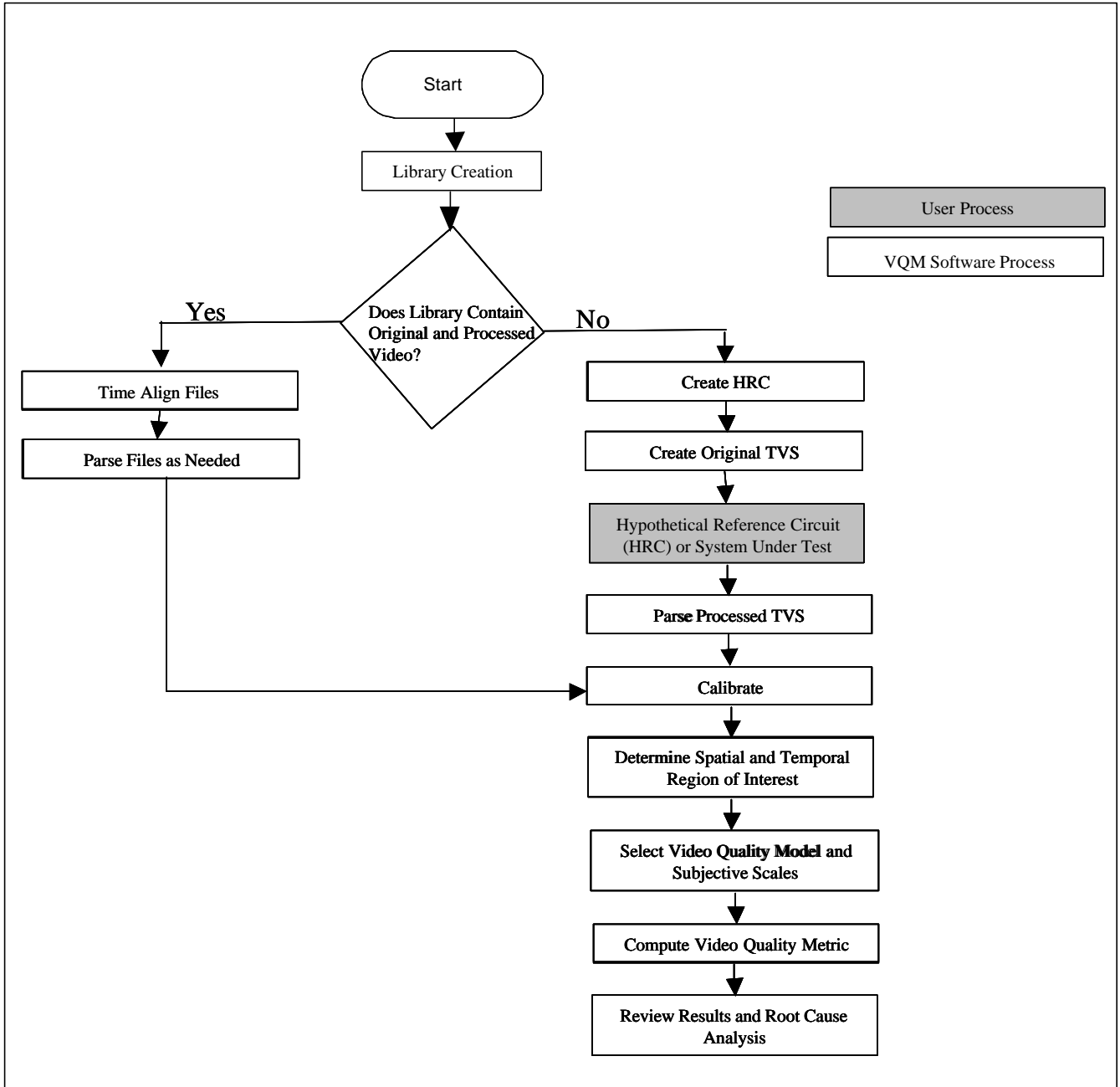


Figure 6. Summary of the two possible VQM software flows.

1.2 Definitions

| Term | Definition |
|-------------|---|
| AVI | Audio Video Interleaved; A file format that is interleaved such that video and audio data are stored consecutively (i.e. a segment of video data is immediately followed by a segment of audio data). |
| Calibration | The operations necessary to estimate and/or correct for Processed Valid Region, Gain/Offset, Spatial Registration, Temporal Valid Region, and Temporal |

| Term | Definition |
|--|---|
| | Registration. |
| Casual Name | The parameter casual name is an abbreviated version of the parameter technical name. |
| CE | Consumer Electronics device |
| Clip | Digital representation of a scene that is stored on computer media. |
| Clip VQM | The VQM of a single clip of processed video. |
| Codec | Abbreviation for an coder/decoder or compressor/decompressor. |
| DirectShow® | The Microsoft® DirectShow software developer's kit (SDK) gives developers access to DirectShow services, which provide playback of multimedia streams from local files or Internet servers, and capture of multimedia streams from devices. Specifically, this SDK enables playback of video and audio content compressed in various formats, including MPEG, Apple® QuickTime®, audio-video interleaved (AVI), and WAV, and both Video for Windows-based capture and WDM-based (Windows Driver Model) capture. |
| Down Sampling | Down sampling is a procedure through which the frame size of a video clip is decreased. |
| Feature | A quantity of information associated with, or extracted from, a spatial-temporal sub-region of a video stream (either an original video stream or a processed video stream). |
| Feature Video | The visual representation, or imagery, of a particular feature's space and time samples. |
| Frame Multiple | The number of frames temporally averaged in the video quality models. |
| Frame Size | Width x Height of a video frame, in pixels. |
| Frequency | Frequency specifies the frequency at which images are examined. Some calibration routines do not need to examine every image from each clip. Rather, the routine will examine one out of every "frequency" images. A small value for "frequency" may result in an unacceptably long calibration run time. |
| Hypothetical Reference Circuit (HRC) | A video system under test such as a CODEC or digital video transmission system. |
| HRC VQM | The VQM of an HRC computed as the average of all the individual Clip VQMs. |
| ITS | Institute for Telecommunication Sciences |
| Library | See Video Library |
| Luminance (Y) | The portion of a video signal that predominately carries the luminance information (i.e. black and white portion of image). |
| National Television Systems Committee (NTSC) | The 525-line analog color video composite system adopted by the US and most other countries (excluding Europe). |
| Original Valid Region (OVR) | The Valid Region of an original video clip, specified in Rectangle Coordinates. For the VQM Software, the default Original Valid Region is the entire frame size independent of Video Format. Here, both pixels and lines are numbered from zero and referenced to video frames that have been sampled in accordance with ITU-R Recommendation BT.601. |

| Term | Definition |
|-------------------------------------|---|
| Original Video | Video that has not been processed or distorted by an HRC. |
| Parameter | A measure of video distortion that is the result of comparing two parallel streams of features, one stream from the original video and the corresponding stream from the processed video. |
| Parameter Video | The visual representation, or imagery, of a particular parameter's space and time samples. |
| PC | Personal Computer. |
| Perception-Based Features | Features that have been extracted from perceptually filtered video. See definition for feature. |
| Perceptually Filtered Video | A video stream that has been filtered to emphasize a particular dimension, or aspect, of perceived video quality (e.g., distortions in motion, edges, and color). |
| Phase-Altering Line (PAL) | The 625-line analog color video composite system adopted predominantly in Europe with the exception of a few other countries around the world. |
| Processed Region of Interest (PROI) | A region of interest extracted from the processed video and corrected for spatial shifts of the HRC, specified in Rectangle Coordinates. |
| Processed Valid Region (PVR) | The Valid Region of a processed video clip from an HRC, specified in Rectangle Coordinates. The PVR is always referenced to the original video before so it is necessary to correct for any spatial shifts of the video by the HRC before computing PVR. Thus, PVR is always contained within the OVR. The region between the PVR and the OVR is that portion of the video that is blanked or corrupted by the HRC. |
| Processed Video | Video that has been processed or distorted by an HRC. |
| Production Aperture | The image lattice that represents the maximum possible image extent in a given standard. The Production Aperture represents the desirable extent for image acquisition, generation, and processing, prior to blanking. For ITU-R Recommendation BT.601, the Production Aperture is 720 pixels x 486 lines for 525-line systems and 720 pixels x 576 lines for 625-line systems. |
| PSNR | The peak signal to noise ratio is 20 times the logarithm (base 10) of the ratio of the peak signal (235 for ITU-R Recommendation BT.601) to the root mean squared error between the processed video signal and the original video signal. PSNR video quality model values are converted to the (0, 1) scale used by the VQM Software with a logistics function. |
| Raw Video | Video without any header information. A raw video file only consists of bits that make the video frames and does not contain any other information such as frame dimensions, frame rate, etc. Raw video is a generic term that can be applied to video in any format (e.g., UYVY, YUV12, YUY2, and RGB24). |
| RGB24 | Uncompressed red, green, blue (RGB) samples with 24 bits per pixel. |
| Root Cause Analysis (RCA) | Root Cause Analysis (RCA) is objective or subjective analysis used to determine the presence or absence of specific video artifacts (e.g., blurring, tiling, or dropped frames) in the processed video. RCA provides the user with detailed information on the likely cause of quality degradations measured by the VQM software. RCA lists a percentage for several possible impairments (e.g., jerky motion, blurring, and error blocks), where 100% indicates that all viewers perceived the impairment as a primary artifact, 50% indicates that viewers perceived the impairment as a secondary artifact, and 0% indicates that the artifact was not perceived. RCA gives an estimate of the impairment <i>type</i> , as opposed to the <i>amount</i> of perceived |

| Term | Definition |
|------------------------------------|--|
| | impairment that is estimated by a VQM model. |
| Root Mean Square Error (RMSE) | The estimated root mean square error between the VQM model output and subjective mean opinion score data, scaled to the default nominal output range of zero (no impairment) to one (maximum impairment). See VQM. |
| Scene | A sequence of video frames. |
| Scene Calibration Methodology | Calibration methods that use the original and processed video scenes, with no a priori knowledge of scene content. |
| SDK | Software Developer's Kit. |
| SGI® | Silicon Graphics, Inc. |
| SMPTE | Society of Motion Picture and Television Engineers; An industry-leading society for the motion picture and television industries devoted to advancing theory and application in motion imaging, including film, television, video, computer imaging, and telecommunications. The industry relies on SMPTE to generate standards, engineering guidelines, and recommended practices to be followed by respective field professionals. |
| Spatial Region of Interest (SROI) | <p>The image lattice (specified in Rectangle Coordinates) that is used to calculate the VQM of a video clip. The SROI is a rectangular subset that lies completely inside the Processed Valid Region. The SROI will be modified by the VQM software to conform to all necessary restrictions (such as being contained within the Processed Valid Region).</p> <p>The recommended SROI for ITU-R Recommendation BT.601 sampled video is 672 pixels x 448 lines for 525-line systems and 672 pixels x 544 lines for 625-line systems, centered within the Production Aperture. This recommended SROI corresponds to approximately the portion of the video picture that is visible on a monitor, excluding the over-scan area.</p> |
| Spatial Registration | The process that is used to estimate and correct for spatial shifts of the processed video sequence with respect to the original video sequence. Horizontal spatial shift is specified in pixels. For progressive systems, vertical spatial shift is specified in frame lines. For interlace systems, the vertical shift of field one and field two are specified separately, each in field lines. |
| Subjective Scores | Quality judgments or Mean Opinion Scores assigned by a panel of viewers watching the video clips. ITS maintains a large database consisting of video clips and their associated subjective scores assigned by viewer panels. |
| Technical Name | The parameter technical name is a very long name consisting of all the information that is necessary to know how the parameter was computed. |
| Test Video Sequence (TVS) | The video sequence that will be applied to an HRC under test. The TVS consists of a color bar followed by pre-selected portions of a video library, delimited by a fixed duration of gray frames. A typical TVS is illustrated in Figure 4. |
| Threshold | A user-defined VQM model score that represents the transition between acceptable and non-acceptable video quality. The Threshold determines the Pass/Fail criteria reported on the first presentation screen following completion of a test. |
| Temporal Region of Interest (TROI) | <p>The specific time segment, sequence, or subset of frames that is used to calculate clip's VQM. The TROI is a contiguous segment of frames that lies completely inside the Temporal Valid Region.</p> <p>The maximum possible TROI is the fully registered time segment and contains all temporally registered frames within the TVR. If reframing is required, the</p> |

| Term | Definition |
|-----------------------------|--|
| | processed clip is always reframed, not the original clip. The TROI will be modified by the VQM software to conform to all necessary restrictions. |
| Temporal Registration | <p>The process that is used to estimate and correct for temporal shifts (i.e., video delay) of the processed video sequence with respect to the original video sequence. Specifically, the VQM Software determines the segment within the processed video file that aligns in time with a corresponding segment from the original video file.</p> <p>Two different algorithms for performing temporal registration are used by the VQM software. One of these is named “sequence-based” and the other is named “frame-based”. The sequence-based algorithm works by correlating a time history of features extracted from the processed video with the same time history of features extracted from the original video (e.g., the sequence-based algorithm might use the total amount of frame-to-frame motion in the sequence). The frame-based algorithm works by finding the best matching original video frame for each processed video frame, and then processes this information to determine the best overall temporal registration. Thus, the frame-based method can produce delay statistics (e.g., minimum, maximum, average) while the sequence-based method can only produce one video delay estimate.</p> |
| Temporal Valid Region (TVR) | The maximum time segment, sequence, or subset of video frames that may be used for calibration and VQM model calculation. Frames outside of this time segment will always be considered invalid by the VQM Software. |
| Uncertainty | Uncertainty specifies the accuracy of the <i>initial</i> temporal registration (i.e., the actual temporal registration is assumed to lie within plus or minus the uncertainty, where the first image in each processed clip is assumed to be temporally registered to the first image in the associated original clip). |
| Up Sampling | Up Sampling is a procedure through which the frame size of a video clip is increased. |
| UYVY | Computer representation of ITU-R Recommendation BT.601 specification, specifically in 4:2:2 color format. A packed YUV format, which means the Y, U, and V samples are packed together into macropixels stored in a single array. A Y-sample at every pixel and a U and V-sample at every second pixel horizontally on each line; with every vertical line sampled. Byte ordering (lowest first) is U0, Y0, V0, Y1, U2, Y2, V2, Y3, U4, Y4, V4, Y5, where the suffix 0 is the leftmost pixel and increasing numbers are pixels increasing left to right. Each 4-byte block is 2 image pixels. This is the native format used by the VQM software, and hence all video must be converted to this format before making quality measurements. |
| Valid Region (VR) | The rectangular portion of an image lattice (specified in Rectangle Coordinates) that is not blanked or corrupted due to processing. The VR is always a subset of the Production Aperture of a video standard and includes only those image pixels that contain picture information that has not been blanked or corrupted. See Original Valid Region and Processed Valid Region. |
| Video Library | A user selected group of video clips, also referred to as a library. |
| Video Quality Metric (VQM) | <p>An overall measure of video impairment reported by a particular VQM model, either for an individual video clip (Clip VQM), or for an HRC (HRC VQM). VQM is reported as a single number and has a nominal default output range from zero to one, where zero is no perceived impairment and one is maximum perceived impairment.</p> <p>Correlation between the VQM and subjective quality was determined using an extensive ITS database of video clips and their associated subjective scores. This database also provided the means for estimating the root mean square error (RMSE) between VQM and subjective mean opinion scores. The VQM Software</p> |

| Term | Definition |
|------------|---|
| | provides a tool to convert from the (0, 1) range of VQM to other subjective scales. See Clip VQM, HRC VQM, and VQM Model. |
| VQM Model | <p>A particular algorithm that is used to compute the VQM and that has been specifically optimized to achieve maximum objective to subjective correlation based upon certain optimization criteria, including the range of quality over which the model applies and the speed of computation.</p> <p>The VQM Software includes five pre-determined VQM models: (1) General – optimized using a wide range of video quality and bit rates, (2) Developer – optimized using a wide range of video quality and bit rates with the added constraint of fast computation, (3) Television – optimized for television (e.g., MPEG-2), (4) Video Conferencing – optimized for video conferencing (e.g., H.263, MPEG-4), and (5) PSNR.</p> |
| Video Type | Interlace or Progressive |
| YUV12 | A planar YUV format, meaning each component is stored as a separate array, the final image being a fusing of the three separate planes. The format consists of an 8-bit Y plane followed by 8-bit 2 x 2 sub-sampled U and V planes. |
| YUY2 | Same as UYVY but with different pixel ordering. Byte ordering (lowest first) is Y0, U0, Y1, V0, Y2, U2, Y3, V2, Y4, U4, Y5, V4, where the suffix 0 is the leftmost pixel and increasing numbers are pixels increasing left to right. Each 4-byte block is 2 image pixels. |

1.3 Related Documents

| Title and Description | Location |
|---|--|
| NTIA Report 02-392, “Video Quality Measurement Techniques”, June, 2002. This document provides a technical description of all the algorithms used by the VQM software. The reader is advised to consult this document to answer any technical questions or clarify any terminology. | www.its.bldrdoc.gov/n3/video/documents.htm |
| NTIA Handbook 02-01, “Video Quality Measurement User Manual”, February, 2002. This document is the User’s manual for the UNIX version of the VQM software. | www.its.bldrdoc.gov/n3/video/documents.htm |
| American National Standards Institute (ANSI) T1.801.03-1996, “Digital Transport of One-Way Video Signals – Parameters for Objective Performance Assessment.” | www.ansi.org |
| Alliance for Telecommunications Industry Solutions (ATIS) Technical Report T1.TR.74-2001, “Objective Video Quality Measurement Using a Peak-Signal-to-Noise-Ratio (PSNR) Full Reference Technique.” | www.atis.org |
| International Telecommunications Union – Radiocommunication Sector (ITU-R) Recommendation BT.601, “Studio Encoding Parameters of Digital Television for Standard 4:3 and Wide-Screen 16:9 Aspect Ratios.” | www.itu.org |

1.4 Miscellaneous

1.4.1 Hardware Platform

The VQM software described in this document was developed and tested on a nominal performance PC whose specifications are described in Appendix A. The video capture and playback capability of the VQM Software was tested on a Silicon Graphics SGI-540® Visual Workstation as given in Appendix A.

2. GETTING STARTED

2.1 VQM Main Screen

Figure 7 shows the VQM Software's main screen. In Figure 7, the user has selected the **File** menu, which has four sub-menus (**New**, **Open**, **Options**, **Exit**). To get started, we will describe the **New**, **Open**, and **Options** sub-menus that are available under the main **File** menu. The main **Tools** menu will be described in detail in section 5.

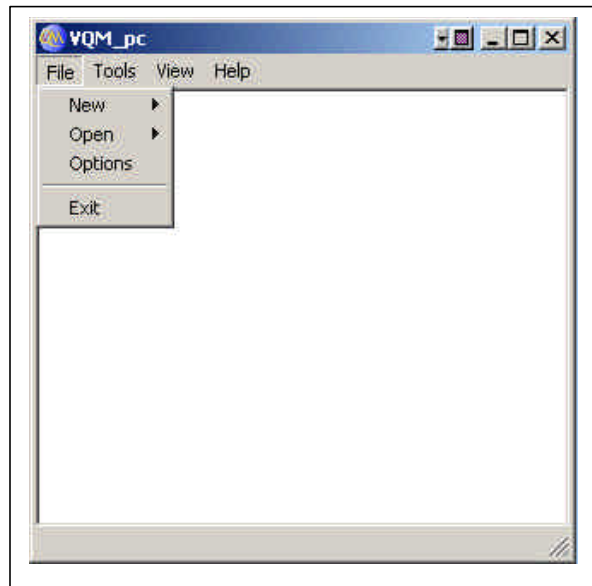


Figure 7. The VQM Software's main screen showing the **File** sub-menus.

The following steps are prerequisites before using the VQM Software to run a video quality assessment test (to be described in section 3, accessed by selecting **File-New-Test**):

1. Set Default Images and Working Directory using **File-Options** (section 2.2).
2. Create a Library using **File-New-Library** (section 2.3).
3. Enter HRC information using **File-New-HRC** (section 2.4).

The user may create a library and enter the HRC information as independent steps (as outlined in sections 2.3 and 2.4) or within the actual test creation process (section 3). The test creation is a type of “wizard” that guides the user through a test setup and execution.

Once Libraries, HRCs, or Tests have been created and saved, they may be loaded into the VQM Software by selecting **File-Open** and then selecting **Library**, **HRC**, or **Test**. This allows the user to save intermediate or final test results and then reload them later for further analysis or examination.

2.2 Default Images and Working Directory

Figure 8 shows the Options dialog popup box when the user selects the **Options** sub-menu from the main **File** menu. Be sure that the default values for each option are correct for the current test.

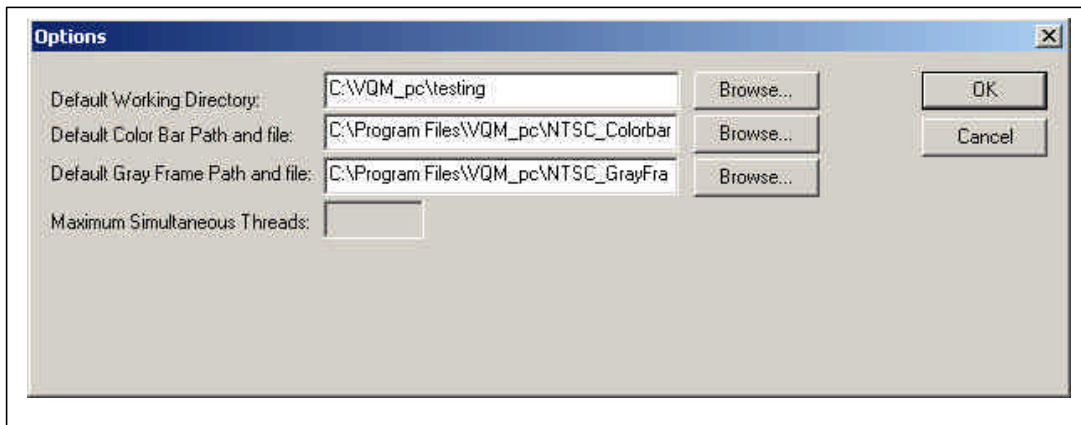


Figure 8. The Options dialog box.

➤ Working Directory

The default working directory for the VQM Software is provided by this location. The VQM software will save any files that are created during the test process to the Working Directory. Click Browse to select a new Working Directory.

➤ Color Bar File

A default Color Car File location is provided for creation of an original TVS (see section 3.2). Select Browse to choose a different color bar file location. The VQM Software is provided with special color bar files in the UYVY Raw Video format for the following spatial resolutions: NTSC (720 x 486 and 720 x 480), CIF (Common Immediate Format, 352 x 288), QCIF (Quarter Common Immediate Format, 176 x 144), SIF (Source Input Format, 360 x 240), QVGA (Quarter VGA, 320 x 240) and one other common low resolution format (240 x 180). These color bars contain special spatial alignment patterns (to assist in the spatial registration process – see section 3.3.2.2). If the user entered both original and processed clips when creating the library, the color bar frame information will be disabled.

➤ **Gray Frame File**

A default Gray Frame File location is provided for creation of an original TVS (see section 3.2). Select Browse to choose a different gray frame file location. Standard Gray Frames in the UYVY Raw Video format are provided for each of the color bar files given above. If the user entered both original and processed clips when creating the library, the gray frame information will be disabled.

2.3 Creating a Library

A library within the VQM Software application is defined as a collection of one or more original and (optional) processed video clips. Specifically, a VQM Software library is an integrated repository that is the basis for all operations within the VQM Software. The VQM Software supports two types of libraries. One that only contains “original video” clips and the other that contains both original and processed video clips. The type of library determines the operation of the VQM Software in the test execution phase of the application. The library is the entry point for video clips that are to be evaluated by the VQM Software.

To create a new library, on the **File** menu, point to **New** and then click **Library**.

The VQM Software presents the library information in a single screen comprised of three tabs: General, Clips, and Parsing and Temporal Registration. The General tab allows the user to enter, update, and view general information about the library – the name and description of the library, frame rate, video color format, video size, and video type (progressive or interlaced). The information in the General tab is the same for all clips within the library. The Clips tab allows the user to add, delete, or view clip information and to arrange clips into a particular order for processing. If the user enters clips into a library that are not in the VQM Software’s native UYVY format, the library will automatically convert the clips from their original color format to the VQM Software’s native UYVY video color format. The VQM Software supports color conversions from the following formats: RGB24, YUV12, and YUY2. The VQM Software also supports the ability for the user to add an AVI file to a library, and automatically remove the header information and color convert the file based upon the color information contained in that header. The optional Parsing and Temporal Registration tab allows the user to time-align clips (referred to in the VQM Software as Temporal Registration) and also allows the user to parse long video clips into shorter sub-clips. Each step is described in more detail below.

Library creation is comprised of initially completing the general library information, identifying the clips to be placed into the library, and optionally aligning and/or parsing clips within the library. If the library contains processed video clips, it is necessary to have the same number of original and processed video clips in the library. Attempting to save a library with an unequal number of original and processed video will result in an error. If the library only contains original clips, there should be **no** processed video clips added.

CRITICAL NOTE

Only clips processed from a single HRC should be added to a specific library. For example, if an original video clip is applied to two different codecs, the two resultant processed files should **NOT** be added to the same library. The calibration module of the VQM Software assumes all clips in a library are from a single HRC, and thus applies the same calibration factors to each clip in the library. Failure to adhere to this practice may result in erroneous data.

2.3.1 General Tab

The General tab prompts the user for the library name, library description, frame rate, video color format, frame size (width and height), and video type (progressive or interlaced). The frame rate and video color format are selected via a drop-down menu. For the user's convenience, standard video frame sizes are selectable via a drop down menu. Non-standard frame sizes can be entered via the frame width and height edit boxes. Figure 9 shows the General tab screen.

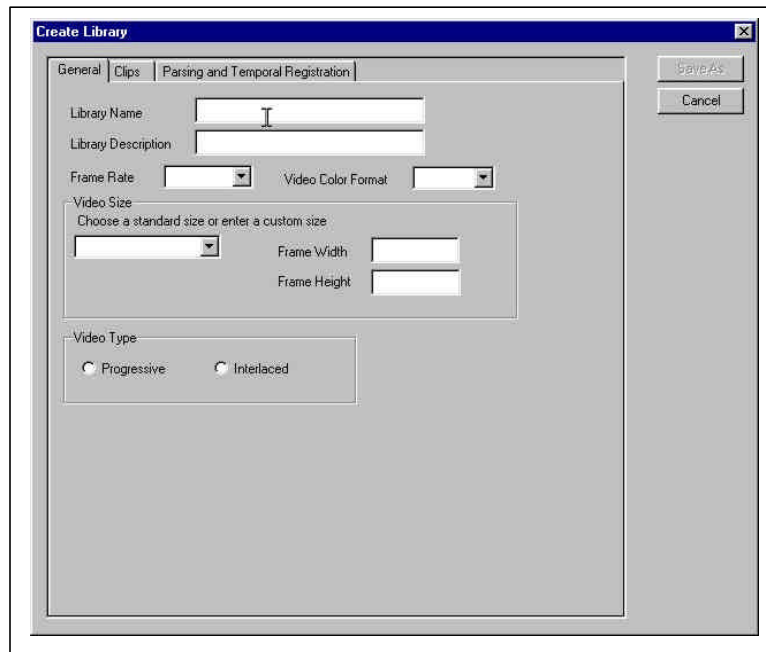


Figure 9. Library creation General menu tab.

➤ Library Name

The user must enter a library name (this is the file name the library will be assigned). When the user saves the file, the name entered in this edit box is the default name to which the library is saved.

➤ Library Description

The user may enter any information regarding the contents of the library. Typically this field is used to provide information on the format or contents of the clips that make up the library.

➤ **Frame Rate**

The Frame Rate drop-down box allows the user to select from the supported frame rates within the VQM Software. Supported frame rates within the VQM Software are 30, 29.97, 25, and 15 frames per second (fps). All clips within a library must have the same frame rate.

➤ **Video Color Format**

The library supports video color format conversion. The VQM Software supports the following color formats: RGB24, UYVY (the VQM Software's native format), YUV12, and YUY2. All clips within a VQM Software library must have the same video color format. Multiple video color formats within a library are not supported unless added to the library in AVI format. The user has the ability to add AVIs of different color formats to the same library. This is made possible because the color format specified within the AVI header will supersede the color format specified by this field.

➤ **Video Size**

The user may select an industry standard video frame size using the drop down box. If the video to be placed in the library is not one of the standard sizes, manual entry of the frame width and height in pixels is supported via the Frame Width and Frame Height edit boxes. The clips within a library must have the same video sizes, as multiple video sizes within a library are not supported.

➤ **Video Type**

The VQM Software supports progressive and interlaced video. All clips within the library must be of the same video type. The user identifies the video type by selecting either the progressive or interlaced radio button.

➤ **Error checking on the General Tab**

The user is required to specify the library name, description, frame rate, video color format, frame size (via drop down selection or entry of frame width and height), and video type (progressive or interlaced). Failure to enter the above information will result in the user not being able to add clips to the library. The user will also not be able to save the library.

➤ **Save As Button**

The Save As button allows the user to save the library information. The Save As button is disabled until all general library information is filled in, and there is at least one original clip in the library. Clicking on the Save As button displays a "Save As" dialog box, with the library name displayed as the default file name. After specifying a file name, and saving the library, the Create Library dialog box is closed.

➤ **Cancel Button**

The Cancel button cancels the library creation process.

2.3.2 Clips Tab

The Clips tab displays a summary of the general library information, and displays two list boxes that display the original and processed (if applicable) video clips that are currently in the library. The Clips tab allows the user to add clips, delete clips, and view clip details. The Clips tab also allows one to re-order the clips so that the VQM Software testing can be conducted in a specified order. A processed clip needs to be directly

(horizontally) aligned with its corresponding original clip for the program to produce meaningful results. The Clips tab allows the user to perform operations pertaining to adding, ordering, deleting, or viewing details of clips within a library. Figure 10 shows the Clips tab before any clips are added.

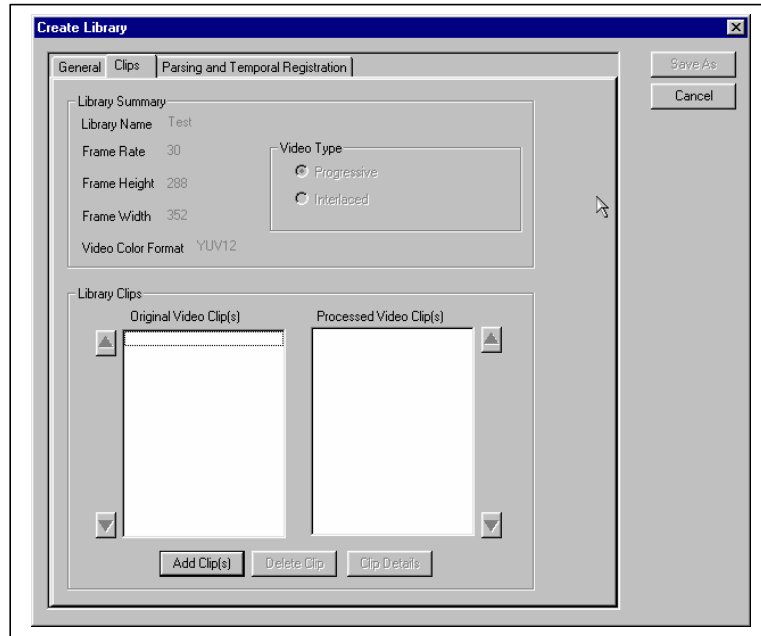


Figure 10. Library creation Clips menu tab before adding any clips.

The list box serves two purposes: to display video clip names, and to display parsed clip names (see Section 2.3.3) with their “parent” clip. Figure 11 shows the clips tab with one clip pair (an original and processed video clip), and also shows parsed video clips from this clip pair. Notice that the “parent clip” is shown in the screen by having the “child clips” indented within the list box. This “parent/child” relationship is maintained throughout the VQM Software. Clip details are available for both “parent” and “child” (parsed) clips.

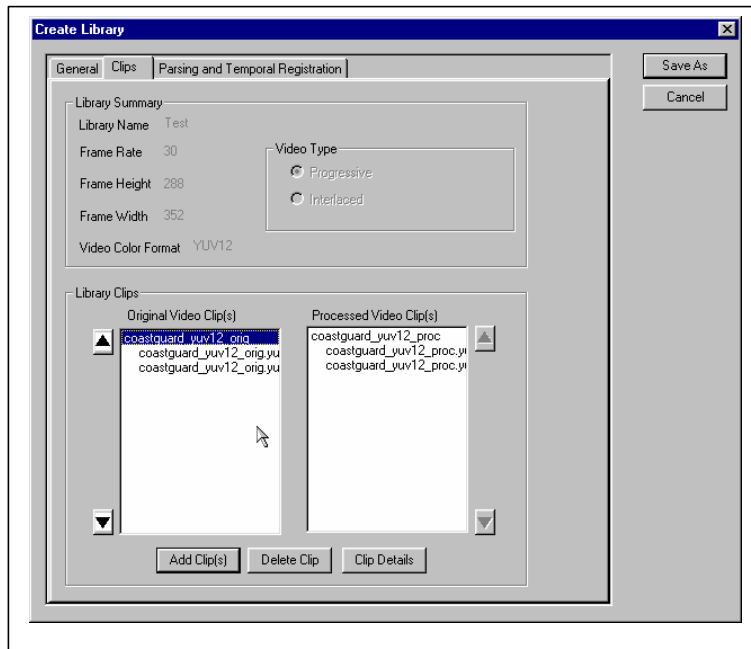


Figure 11. Library creation Clips menu tab.

➤ **Add Clip Button**

The Add Clip button allows the user to add an original (and optionally, a processed) video clip into the library. When the Add Clip Button is pressed, the Add Clip dialog box will be displayed. See section 2.3.2.1 for more information on the Add Clip dialog box.

➤ **Clip Details Button**

Highlighting the clip and either double-clicking the clip or selecting the Clip Details button will allow the user to view the clip details for the selected clip.

➤ **Re-ordering Clips**

When more than one clip exists in a library, clips can be re-ordered by using the up and down arrow keys to the left and right of the list boxes. The original video clips are re-ordered with the up and down arrow keys to the left of the list box, while the processed video clips are re-ordered with the up and down arrow keys to the right of the list box. To re-order the clips, the user selects the clip to be moved, and clicks the up or down arrow as appropriate. If clips have been moved after parsing and temporal alignment, the user should re-specify the parsing and temporal registration parameters for the newly formed clip pair. It is critical the user keeps the original and processed clips pairs aligned side-by-side when re-ordering original and processed clips.

➤ **Delete Clip Button**

The Delete Clip button allows the user to remove a clip from the library. If the user wishes to delete a clip pair, the pair must be deleted together, as only one original or processed video may be deleted at a time. The Delete Clip button is enabled when the user has selected an original or processed clip. The user will be prompted to confirm the

deletion of the clip. If the user deletes a “parent clip”, all child clips are deleted with the parent. Figure 12 shows the delete clip confirmation screen.

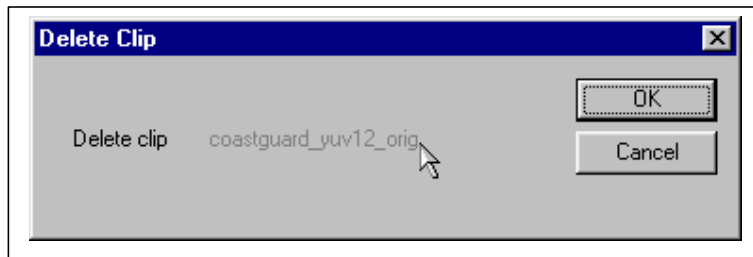


Figure 12. Delete clip confirmation screen.

The user can choose to delete the clip (and children clips if this is a parent clip) by clicking the OK button, or Cancel the operation by clicking on the Cancel button.

2.3.2.1 Add Library Clip Dialog Box

The Add Library Clip dialog box allows the user to enter original and (optionally) processed video clips into the library in a single operation. Original and processed video clips allow the user to enter the file name, clip name (to be displayed), and a description of the clip. The user may specify the Original Valid Region (OVR) of the original clip and can also view the original and processed video using this screen. This screen will initiate (if necessary) a color conversion task to convert the file into the VQM software’s native video format (UYVY). For AVI files, this color conversion process will also initiate stripping of the AVI header information. The Add Library Clip dialog box displays a summary of the general video information, such as frame rate, frame size, video color format, and video type.

CRITICAL NOTE

It is strongly recommended that the user place clips with at least five seconds of video into the library (even longer clips are preferred). While the VQM Software supports minimum clip lengths of four seconds, usable clip duration will be adjusted downward by the VQM software to satisfy constraints in later processing steps (calibration, model selection).

The Add Library Clip dialog box is reached by pressing the Add Clip button on the Clip Tab of the Create Library box. Figure 13 below shows the Add Library Clip dialog box. If the user has processed clips on disk, both the original and processed clip fields will be completed. If the user has only original clips (i.e., TVS creation process enabled), only the original clip information that will be integrated into the TVS is entered.

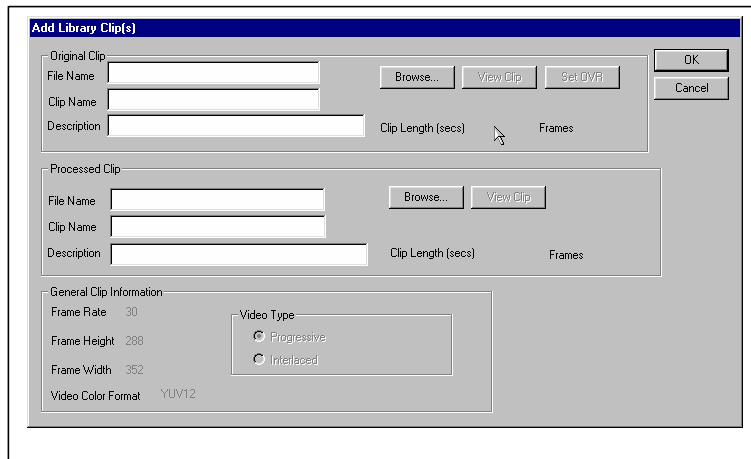


Figure 13. Add Library Clip dialog box.

The following describes the fields and operations within the Add Library Clip dialog box:

ORIGINAL CLIP

➤ File Name

This is the full path name for the video clip to be added.

➤ Clip Name

By default, this is the filename of the original clip. This field is automatically filled in when the user types in the File Name, or clicks the Browse button to browse for and select a clip. The user has the option to change this field if they wish.

➤ Clip Description

The user may enter a text description for the clip.

➤ Browse

Clicking the Browse button displays a standard file selection dialog to enable the user to use the graphical interface to specify the filename of the clip.

➤ View Clip

The View Clip button allows the user to view the clip. If color conversion is required, the color-converted clip will be displayed. The View Clip button is not active until a valid clip filename has been entered manually or via the browse option.

➤ Set OVR

The Set OVR button displays the Set OVR dialog box. The Set OVR dialog box (described below under the heading “SET OVR (CLIP ORIGINAL VALID REGION DIALOG BOX)”) allows the user to manually or graphically set the OVR for the original clip. The Set OVR button is not active until a valid clip filename has been entered manually or via the browse option. The user is encouraged to set the OVR to the correct valid region for each original video clip.

➤ Clip length and number of frames

The screen displays the clip length (in seconds), and number of frames in the clip. These fields are not editable by the user.

PROCESSED CLIP

➤ **File Name**

This is the full path name for the video clip to be added.

➤ **Clip Name**

By default, this is the filename of the processed clip. This field is automatically filled in when the user types in the File Name, or clicks the Browse button to browse for and select a clip. The user has the option to change this field if they wish.

➤ **Clip Description**

The user may enter a description for the clip.

➤ **Browse**

Clicking the Browse button displays a standard file selection dialog to enable the user to use the graphical interface to specify the filename of the clip.

➤ **View Clip**

The View Clip button allows the user to view the clip. If color conversion is required, the color-converted clip will be displayed.

➤ **Clip length and number of frames**

The screen displays the clip length (in seconds), and number of frames in the clip. These fields are not editable by the user.

NOTE: The processed video clip does not have a Processed Valid Region (PVR) option, as this is automatically calculated or manually entered in the calibration module.

GENERAL OPERATIONS

➤ **OK button**

The OK button allows the user to close the dialog box and save the changes to the library. If no clip is specified, the operation is aborted.

➤ **Cancel button**

The Cancel button cancels the current operation and returns the user to the Clips tab of the library creation screen.

➤ **Color Conversion**

The VQM Software supports color conversion of video clips placed into the library. When the user adds an original or processed clip that is not in the VQM Software's native UYVY color format, the color conversion algorithm is called to convert the clip from its original color format to the VQM Software's native UYVY format.

➤ **Error checking**

The Add Library Clip dialog box verifies that the clip file name is valid, that the clip name and description have been filled in, and that the clip is at least 4 seconds in duration. Clips are validated upon leaving the Clip Filename edit box.

VIEW CLIP DIALOG

The View Clip dialog box, available for both original and processed video clips allows the user to view the video clip. The View Clip dialog box is essentially the same as

Figure 15 below, except that there is no provision for visually setting the OVR by moving the blue OVR lines (i.e., the blue OVR lines will not be present).

SET OVR (CLIP ORIGINAL VALID REGION DIALOG BOX)

The Clip Original Valid Region dialog box is only available for original video clips. The Clip Original Valid Region dialog box can be displayed after the user has specified a valid clip file name (manually or via the Browse button). The user displays the Clip Original Valid Region dialog box by clicking the Set OVR button from the Add Library Clip dialog box. Figure 14 below shows the Clip Original Valid Region dialog box.

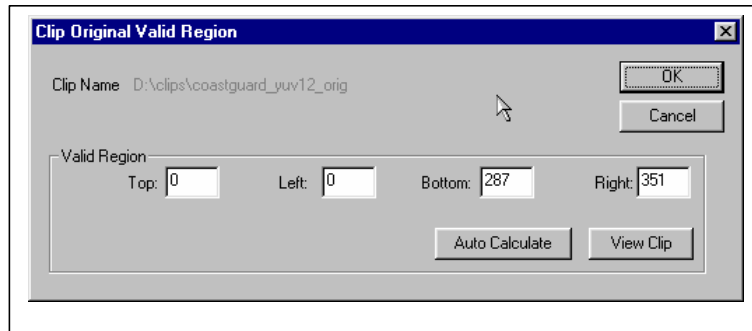


Figure 14. Clip Original Valid Region dialog box.

The user has three methods to set the original valid region:

- Manually enter the valid region by specifying the top, left, bottom, and right values (in pixels).
- Allowing the VQM Software to automatically calculate
- Visually setting the original valid region.

The default value for the OVR is the entire video frame size. The OVR is manually specified by entering values (in pixels) into the Top, Left, Bottom, and Right edit boxes. Note the manual entry fields expect the actual frame pixels to be included in the OVR. In Figure 14, the OVR is an entire CIF frame (352 x 288, 0-based origin). If the user wished to reduce the OVR to a two-pixel safety margin in the above example, the fields would read 2, 2, 285, and 349, respectively. When the Auto Calculate button is selected, the VQM software automatically estimates the OVR for the clip and adds a small safety margin.

The View Clip button in the Clip Original Valid Region dialog box enables the user to visually set the OVR by dragging the blue dashed lines with the mouse. Figure 15 shows the View Clip Screen for visually setting the OVR, with the OVR region displayed as a blue line.



Figure 15. View Clip screen for visually setting the OVR.

The user can play the video, or step through the video with the Play and Next buttons. The user can also reset the video to the beginning or end of the video clip with the start and end buttons, respectively.

2.3.2.2 *Clip Details Dialog Box*

The Clip Details dialog box on the Clips tab of the library screen allows the user to view the clip information. The screen allows the user to update some information such as the clip name, description, and OVR (if the clip is an original clip). The screen also allows the user to view the clip. The functionality of the Clip Details dialog box can also be accessed by double clicking on the clip displayed in either the original or processed clip list box. Figure 16 shows the Clip Details dialog box.

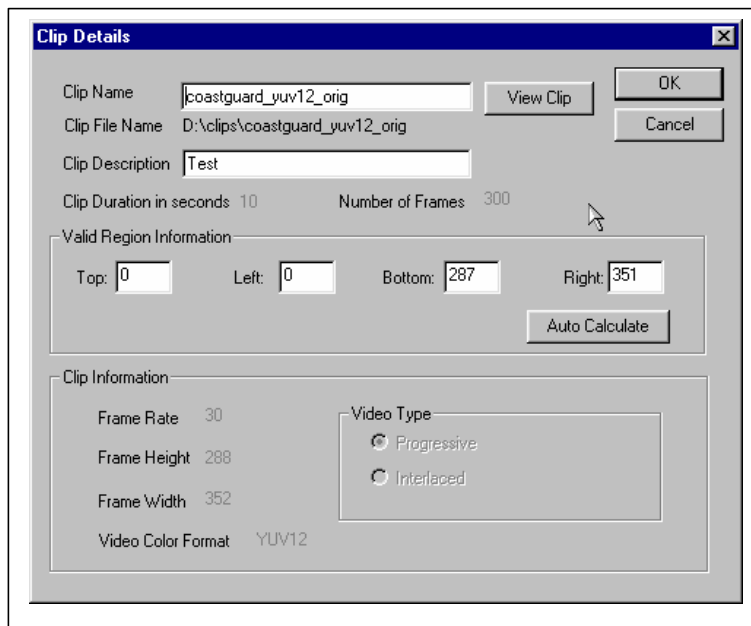


Figure 16. Clip Details dialog box.

2.3.3 Parsing and Temporal Registration Tab

The Parsing and Temporal Registration tab allows the user to perform two related functions on video clips. Temporal registration is only applicable for libraries containing original and processed video clips. Temporal registration is the alignment of original and processed video clips such that frame 0 of the original clip matches frame 0 of the processed clip, exactly the same as is done in calibration (see section 3.3.2.5). The recommended method for performing these two operations is to first temporally align the clip, then parse the clip if necessary. Figure 17 shows the Parsing and Temporal Alignment tab. Note that if a file is first temporally registered, and then parsed, the parsed sub-clips (children) must be temporally registered during calibration. If the video file is temporally registered and not parsed, then temporal registration may be skipped in the calibration section.

Automatic parsing is the segmentation of a video clip into one or more pieces at a given parse frequency and length. Parsing is typically used if the original clip is longer than the VQM Software's clip duration limit of thirty seconds. Parsing allows the user to segment the clip into shorter duration clips that can be accepted by the VQM Software. Manual Parsing allows the user to visually set the points that will be used by the VQM Software to parse the clip.

If an OVR is set for a parent clip before it is parsed, the children will inherit that OVR. This dialog can be used to update the OVR of the individual child clips after parsing has taken place. This functionality may be useful if an original clip contains multiple scenes with different OVRs.

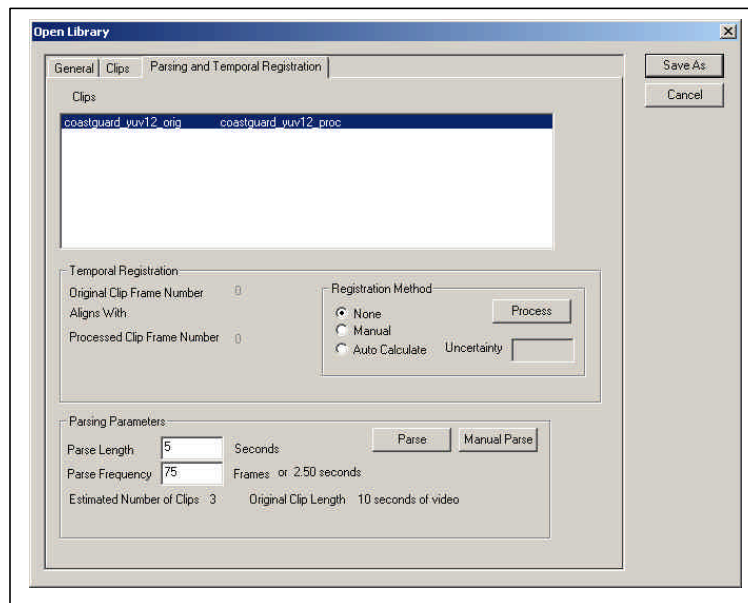


Figure 17. Parsing and Temporal Registration tab.

The Parsing and Temporal Registration tab displays clips, temporal registration information, and parsing parameters for the clips. Temporal registration is only enabled

if the highlighted clip is a clip pair (i.e., an original clip with a corresponding processed clip).

TEMPORAL REGISTRATION

Temporal registration is the process for aligning clip pairs. Temporal registration has three options: None, Manual, or Auto Calculate. The temporal registration options are active when a clip pair has been selected by highlighting it in the Clips List box. The original and processed frame numbers are shown to the left of the Temporal Registration Method group box.

➤ None Radio Button

Selecting the None option for temporal registration will result in temporal registration being reset to the first frame for both original and processed clips. This reset action occurs when the Process button is pressed.

➤ Manual Radio Button

Selecting Manual for temporal registration will result in the Manual Temporal Registration dialog box being displayed when the Process button is pressed. Figure 18 shows the Manual Temporal Registration dialog box. The Manual Temporal Registration dialog box displays both the original and processed clips, and allows the user to manually align the clips. Each clip has three buttons associated with the alignment operation. They are Begin, Prev, and Next. Begin resets the clip viewer to frame 0 (first frame) of the clip, Prev steps the clip back one frame, and Next steps the clip forward one frame. The Mark button will set the current alignment as the temporal registration position. The OK button will set the position that the user has marked as the temporal registration value for the clip and close the window.

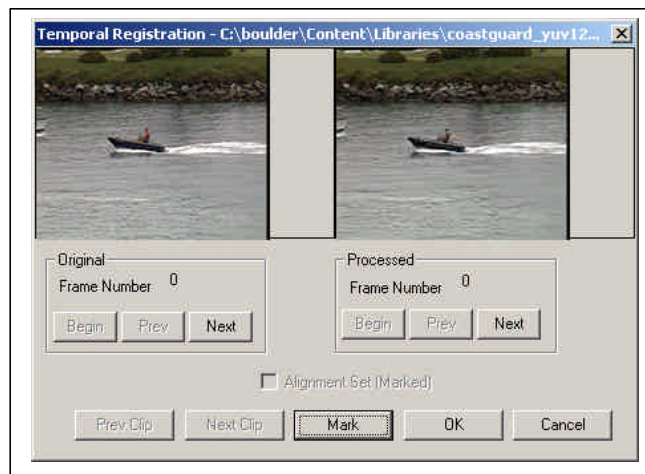


Figure 18. Manual Temporal Registration dialog box.

➤ Auto Calculate Radio Button

The Auto Calculate button allows the VQM Software to temporally align the clip pair for the user when the Process button is pressed. The Auto Calculate process evaluates the clip pair programmatically, and determines the best temporal alignment between frames in the processed clip and frames in the original clip.

➤ **Process Button**

The Process button activates the temporal registration method that the user has selected via the radio buttons. If no radio button is selected, nothing happens. If the original clip and processed clip vary in duration (i.e. the HRC has dropped video frames), the VQM Software will first pad the end of the shorter clip with the appropriate number of gray frames to ensure that the original and processed clips are equal in duration. Next, the VQM Software temporally aligns the clip pair. After alignment, the first frame of the original clip (frame 0) aligns to some frame X of the processed clip. If the HRC dropped frames from the beginning of the processed clip, then the VQM Software will discard X frames from the beginning of the original clip and pad X gray frames to the end of the original clip. The file extensions for temporal aligned video clips are “.ta”; the extension for padded clips is “.pad”. It is possible for a clip to be temporally aligned and padded, so an extension of “.ta.pad” is possible. The extensions are placed in addition to any extensions already associated with the clip. For example, if the original clip was “myoriginal.yuv”, and it was padded and temporally aligned, the new clip that would be used within the VQM Software would be “myoriginal.yuv.ta.pad”.

PARSING PARAMETERS

Clip parsing is the segmentation of a clip into one or more sub-clips and is primarily used if the video clip exceeds the VQM Software’s maximum duration of thirty seconds. The sub-clips are associated with the “parent clip”, and are removed if the parent clip is removed from the library.

➤ **Parse Length Edit Box**

The Parse Length edit box allows the user to specify the parse length of the parsed clips. This is between 4 and 30 seconds in duration, and is specified as whole numbers only. Parse Length is only used when automatic parsing is selected, by pressing the Parse button.

➤ **Parse Frequency Edit Box**

The Parse Frequency determines the interval (in frames) between the first frames of successively parsed video clips (where each parsed clip will be of Parse Length seconds). Thus, Parse Frequency can be used to generate overlapping or non-overlapping parsed video clips. Parse Frequency has a minimum of one frame (i.e., a new clip is generated at every frame). Parse Frequency is only used when automatic parsing is selected, by pressing the Parse button.

➤ **Parse Button**

Automatic clip parsing will be performed when the Parse button inside the Parsing Parameters box is pressed. If a clip pair has been selected, both the original and processed clips will be parsed in the same manner. Automatic clip parsing accepts two parameters: the Parse Length, and the Parse Frequency. The Parse Length is the duration of the parsed clip in whole integer seconds. The Parse Frequency defines the interval (in frames) between successively parsed video clips. For example, if a 120 second video clip has a frame rate of 30 frames per second, a Parse Length of 5 seconds, and Parse Frequency of 150 frames, the VQM Software will generate 24 clips that are each of 5 seconds duration when the Parse button is pressed. In this example, none of the clips are

overlapping. If the parse frequency had been set to 100 frames, 36 clips would have been generated with a 50-frame overlap between successive clips.

➤ **Manual Parse Button**

Figure 19 shows the window that will open when the Manual Parse button is pressed. This window allows the user to set parse points visually in a clip. The user is given many options to navigate through the clip. The '|<' button will take the clip to the beginning, the '<' button will step the clip back one frame, the '>' button will step the clip forward one frame, and the '>|' button will take the clip to the last frame. The Go To Frame edit box allows the user to type in the frame that they wish to jump to (pressing the 'Go' button the jump to the specified frame).

To set a parse point, there must be a valid frame number in the Parse Start Location edit box and the Parse End Location edit box must contain a frame number that is at least 4 seconds greater than the Parse Start Location. If this is the case, the 'Parse' button may be pressed to set a parse point.

If at any time the user wishes to delete a set of parse points they may do so by selecting the points to be deleted in the large list box at the bottom of the screen and pressing the 'Delete' button. When all parse points have been set, pressing the OK button will return to the Parsing and Temporal Registration screen in the Create Library process. The cancel button will exit the screen without saving any parse points.

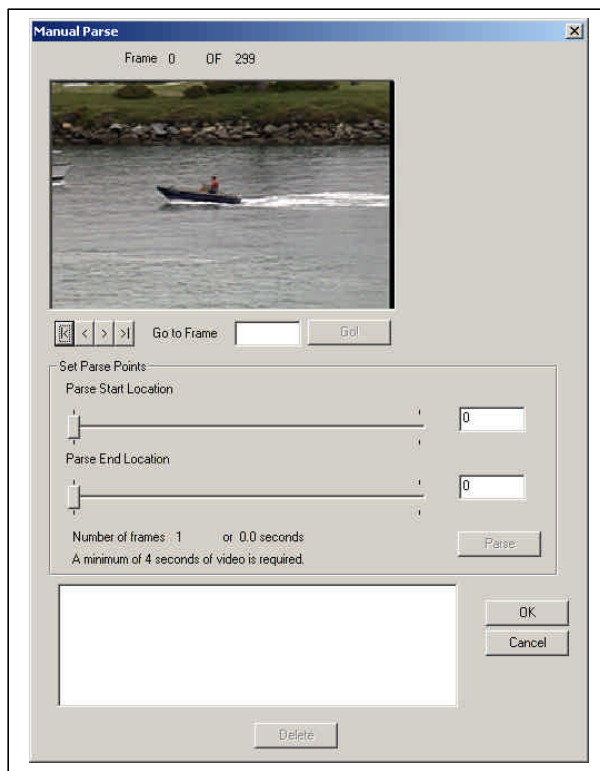


Figure 19. Manual Parse dialog box.

2.4 Entering HRC Information

The next step after library creation is to enter information about the HRC. This information will be stored in the test file (see section 3.1). Note that the test will contain information specific to the HRC. The user is cautioned against applying processed files to other HRCs in order to prevent errors during calibration. To enter new HRC information, on the **File** menu, point to **New** and then click **HRC**. The screen is shown in Figure 20 below.

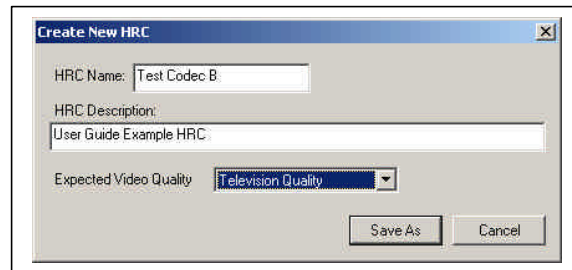


Figure 20. Create New HRC dialog box.

CRITICAL NOTE

Only clips processed from a single HRC should be added to a specific library. For example, if an original video clip is applied to two different codecs, the two resultant processed files should **NOT** be added to the same library. The calibration module of The VQM Software assumes all clips in a library are from a single HRC, and thus applies the same calibration factors to each clip in the library. Failure to adhere to this practice may result in erroneous data.

➤ HRC Name

The user must enter an HRC name (this is the file name the HRC will be assigned). The HRC is saved such that it can be selected any time a new test is created.

➤ HRC Description

The user may enter any information regarding the HRC. Typically this field is used to provide information on the type of HRC (codec, transmission system, model numbers, revision numbers, etc.)

➤ Expected Video Quality

The user is given three choices for the expected quality of processed video from the HRC. The choices are Television Quality, Video Conferencing Quality, and Unknown Quality. The choice here will determine the default temporal registration method used during calibration (see section 3.3.2.5).

3. RUNNING A TEST

The following steps must be followed to conduct a video quality assessment test using the VQM Software:

1. Creating a Test
2. Process TVS (if necessary)
3. Calibration
4. Selecting Models
5. Defining Region of Interest

After each step in the video quality test, the VQM Software provides the following buttons at the bottom of the screen:

➤ **Save**

Press Save to save and continue a test.

➤ **Finish**

Press Finish at any time to save and close a test.

➤ **Next**

Press Next to move from step to step.

➤ **Back**

Press Back to discard current results and go back to the previous step.

➤ **Cancel**

Press Cancel to close a test without saving.

3.1 Creating a Test

To create a new test, on the **File** menu, point to **New** and then click **Test**. This screen shown in Figure 21 will be displayed. The user must provide the VQM Software with information about the library, the Color Bar Frame and Gray Frame (necessary for tests that utilize a TVS, see Figure 4), the working directory, and the HRC that will be evaluated. The user may start by creating a test without first performing the library and HRC steps outlined in sections 2.3 and 2.4 (the software will prompt for these steps when required). If the library being used contains both original and processed video clips, the Process TVS (see section 3.2) portion of the test creation process will be skipped.

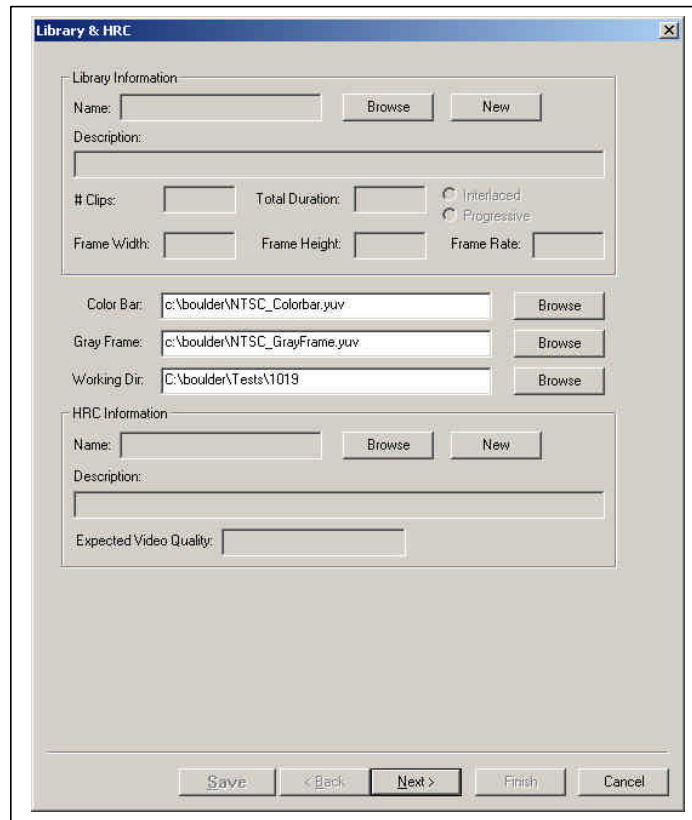


Figure 21. Library and HRC dialog box for creating a new test.

LIBRARY INFORMATION

Specify Library Information by selecting one of the following buttons.

➤ **Browse Button**

Select Browse to choose a previously created library.

➤ **New Button**

Select New to create a new library. See section 2.3.

DEFAULT IMAGES AND WORKING DIRECTORY

The following options may be set to default values using the **Options** menu available on the main VQM screen. Be sure that the default values for each option are correct for the current test.

➤ **Color Bar Frame**

A default Color Car File location is provided for creation of an original TVS (see section 3.2). Select Browse to choose a different color bar file location. The VQM Software is provided with special color bar files in the UYVY Raw Video format for the following spatial resolutions: NTSC (720 x 486 and 720 x 480), CIF (Common Immediate Format, 352 x 288), QCIF (Quarter Common Immediate Format, 176 x 144), SIF (Source Input Format, 360 x 240), QVGA (Quarter VGA, 320 x 240) and one other common low resolution format (240 x 180). These color bars contain special spatial alignment patterns (to assist in the spatial registration process – see section 3.3.2.2). If the user entered both

original and processed clips when creating the library, the color bar frame information will be disabled.

➤ **Gray Frame**

A default Gray Frame File location is provided for creation of an original TVS (see section 3.2). Select Browse to choose a different gray frame file location. Standard Gray Frames in the UYVY Raw Video format are provided for each of the color bar files given above. If the user entered both original and processed clips when creating the library, the gray frame information will be disabled.

➤ **Working Directory**

The default working directory for the VQM Software is provided by this location. The VQM software will save any files that are created during the test process to the Working Directory. Click Browse to select a new Working Directory.

HRC INFORMATION

Specify the HRC information by selecting one of the following buttons:

➤ **Browse Button**

Select Browse to choose a previously created HRC.

➤ **New Button**

Select New to create a new HRC. See section 2.4.

When all of the information has been entered, press the Next button to continue. If the library contains only original video sequences, the user is taken to the processed TVS module described in section 3.2. If the library contains both original and processed video clips, the user is taken directly to the calibration module (section 3.3). Please see Figure 6 for an overview of the VQM software flow.

3.2 Process TVS (No Processed Clips in Library)

If the user has created a test with a library that contains only original video clips, the user is taken through the Process TVS software module described here. Process TVS consists of taking the pre-selected library and creating a TVS. Figure 4 provides a pictorial representation of the relationship between clips, the library, and the TVS. In words, a library is a collection of clips, and a TVS is a library with leading gray frames, color bar frames (for calibration), gray frames between the clips, and trailing gray frames. As indicated previously, if a library contains both original and processed video clips, this step is skipped in its entirety. Process TVS is useful for users that want to create a long original sequence that contains many smaller clips, inject this original video stream into an HRC, and then analyze the resulting processed video stream. Figure 22 shows the Process TVS screen.

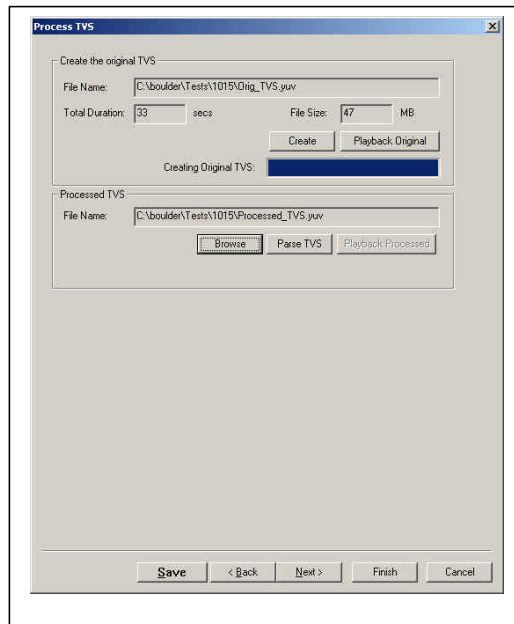


Figure 22. Process TVS screen.

CREATE THE ORIGINAL TVS

➤ File Name Edit Box

The user first enters a file location name for the TVS to be created. By default, the file will be saved in the Working Directory but the user may save the file to any location. The Total Duration and File Size boxes are automatically updated.

➤ Create

The user selects Create and the TVS is automatically created (gray and color bar frames are automatically inserted at the proper locations). This time required to complete this step will vary depending upon the number of clips and their durations.

➤ Playback Original

Playback Original allows the user to view the original TVS (with gray and color bar frames inserted).

CREATING A PROCESSED TVS (NOT PART OF THE VQM SOFTWARE)

The user must now take the original TVS (that was saved to disk during the original TVS creation process) and produce a processed TVS using the HRC specified in section 2.4. The processed TVS must be given a new file name and be in the UYVY format. The flow is illustrated in Figure 6. If the processed TVS is not in UYVY format, the user may use the Color Convert to UYVY Tool in the **Tool** menu to convert the file from its inherent color format to the UYVY color format.

There are a variety of methods to complete this step depending upon the type of HRC being evaluated and the type of video equipment that is available to the user. The VQM

Software also provides a Capture Video tool that can be used to capture a processed TVS directly to hard disk (see section 5.1).

➤ **Browse**

Once the processed TVS file has been created, select the Browse button to specify the processed TVS file name.

➤ **Parse TVS**

The VQM Software must parse the processed TVS. Parsing in this context refers to stripping the gray and color bar frames away and automatically saving the individual processed video clips to disk. This step can only be performed after both the original TVS and processed TVS are stored on disk and their file names are specified in the appropriate dialog boxes. The user selects the Parse TVS button to automatically parse the processed TVS. The VQM Software then automatically parses the selected processed TVS. The individual processed clips and processed color bar frames will be used in subsequent calibration and computation steps. The user may view the individual parsed clips or may view the entire processed TVS using the VQM Software's UYVY Player (see section 5.6). This time required to complete this step will vary depending upon the number of clips and their durations.

When the Processed TVS has been processed, press Next to continue with Calibration (section 3.3).

3.3 Performing Calibration

Calibration is the process of removing from the processed TVS those impairments which viewers do not see or are seen but not found to be objectionable. Calibration may be used to determine if proper engineering practices have been followed in the design of the HRC under test (e.g., the video system gain should be 1.0). Normally, calibration problems in an HRC can be systematically corrected or removed. The calibration steps consist of Temporal Valid Region, Spatial Registration, Processed Valid Region, Gain/Offset, and Temporal Registration.

Warning: Calibration may take a very long time to complete.

3.3.1 Calibration Using Default Options

The VQM Software has a number of options that specify how calibration is to be performed. **In most cases, it is recommended that the user select the default options for calibration.** To calibrate using default options, simply press the Next button (Figure 23) and go to section 3.4.

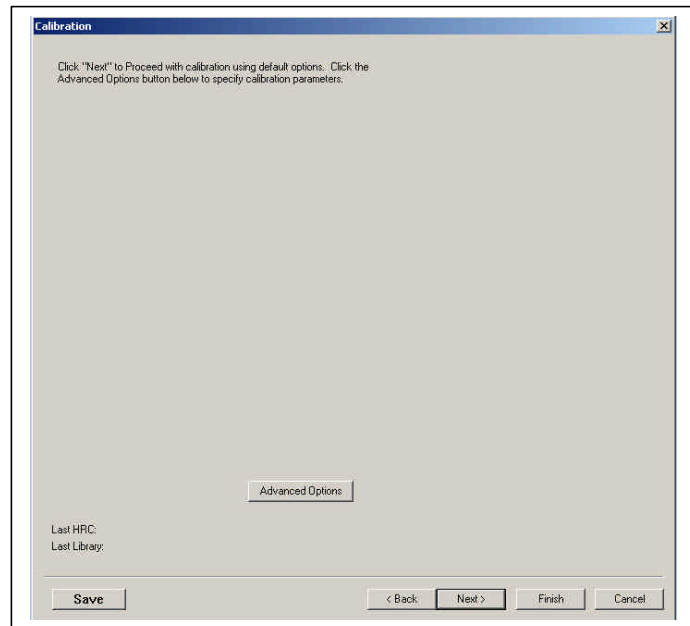


Figure 23. Calibration Options screen.

3.3.2 Calibration Using Advanced Options

To choose other calibration options, press the Advanced Options button in Figure 23. Figure 24 shows the Advanced Calibration Options screen that pops up. If the user knows that the HRC does not have any calibration problems (e.g., spatial shifts, temporal shifts, a gain different than 1.0), then the None calibration options can be selected. Manual calibration options are also available if the calibration quantities are already known. The time required to complete each calibration step will vary depending upon the number of clips, their durations, and the selected calibration options. The None and Manual calibration options are much quicker but the user must have a prior knowledge of the calibration quantities to use these options.

When you are satisfied with the advanced calibration options, press OK to return to the main calibration screen or Cancel to accept the previous settings. You may also choose Set to Defaults to return the calibration settings to their default options. Then, press the Next button to perform the selected calibration and go to section 3.4.

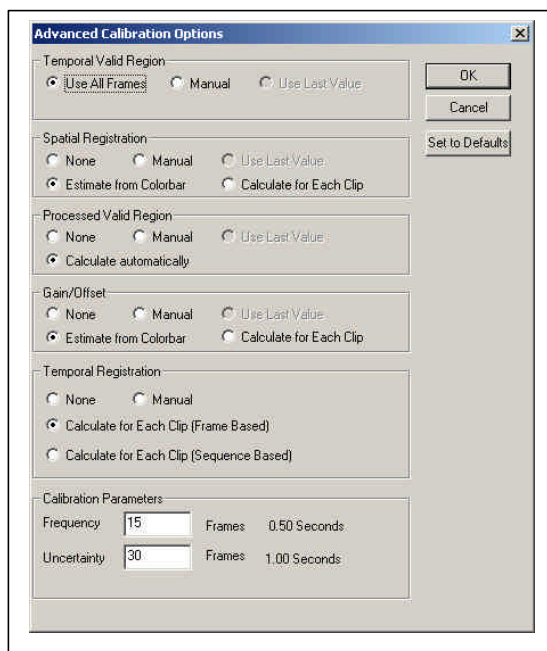


Figure 24. Advanced Calibration Options popup screen.

3.3.2.1 **Temporal Valid Region**

The temporal valid region (TVR) is a sub-sequence of frames within a processed video clip that contain valid video. A sequence of frames at the beginning and/or end of each clip may be marked invalid, meaning that the calibration and model software modules will not consider these video frames for computations. As an example, if a video conferencing codec exhibits dynamic time warping or frame loss (i.e. fifteen seconds of original video produces twelve seconds of processed video) the VQM Software's padding feature would modify the processed video clip by adding three seconds of gray at the end of the clip. Note that the gray padding can occur in cases where the original and processed video clips exist in a library as well as when an original TVS was created and used to produce a processed TVS. In the above example, the TVR could be set to the valid twelve seconds of video.

➤ **Use All Frames**

All frames will be used by subsequent software modules.

➤ **Manual**

The user will be presented with a screen to manually enter the number of frames to be *discarded* from the beginning and end of each video clip. The default values are 0 (i.e., do not discard any frames).

➤ **Use Last Value**

In the case the user has completed a previous test and wishes to use the same calibration results, the user may select the Use Last Value option. This option is only recommended if the same HRC is being tested twice consecutively.

3.3.2.2 Spatial Registration

Many video systems spatially shift the image. For example, the image may be shifted ten pixels to the left and four lines up. Spatial registration detects and removes the spatial shift introduced by the HRC under test. Each video system or HRC is assumed to have only one spatial shift. If the HRC spatially shifts the video image, skipping the spatial registration (i.e., selecting the None option) may result in predictions of video quality that are worse than expected.

➤ **None**

No HRC Spatial Registration calibration will be performed. The processed video is assumed to be spatially registered to the original video.

➤ **Manual**

For Interlaced video, the user will be presented with a screen to manually enter the number of pixels to shift horizontally, as well as the number of lines to shift vertically for each field (field 1 and field 2, separately entered). For progressive video, the user will be presented with a screen to manually enter the number of horizontal pixels and the number of frame lines. The default values are 0.

➤ **Estimate from Color Bar**

The VQM Software automatically calculates the required shifts from the special color bar in the TVS. This option is invalid and is disabled for tests conducted on libraries containing both original and processed video clips.

➤ **Use Last Value**

In the case the user has completed a previous test and wishes to use the same calibration results, the user may select “Use Last Value”. This option is only recommended if the same HRC is being tested twice consecutively.

➤ **Calculate for Each Clip**

The VQM Software automatically calculates the required shifts for each clip and uses them to determine the best estimate for the HRC spatial shift.

3.3.2.3 Processed Valid Region (PVR)

Many digital video systems fail to transmit all the image pixels around the edge of the image and then insert black image pixels to form a black border around the image. This technique is popular since NTSC video includes an over scan area that is not normally seen by the viewer and an HRC can reduce the bits required to compress or transmit the video stream. In addition, video quality measurements should not be made on these over scan areas because the viewer does not see impairments in the over scan area. The Processed Valid Region (PVR) detection algorithms detect the valid portion of the processed video and discard pixels outside of that area from further consideration. Each video scene can have a different PVR. A PVR that is specified too large may result in predictions of video quality that are worse than expected.

➤ **None**

No PVR calibration will be performed. In this case, the PVR will be set to that portion of the original valid region (OVR) that is not invalidated by the spatial shift results.

➤ **Calculate Automatically**

The VQM Software automatically calculates the PVR for each scene.

➤ **Manual**

The user will be presented with a screen to manually enter pixel coordinates for the PVR. The PVR is required to lie within the original valid region (OVR) since PVR is referenced to the original image coordinates (i.e., the processed video is spatially shift corrected). The requested PVR will be modified to eliminate the portion invalidated by the spatial registration results.

3.3.2.4 Gain/Offset

Many video systems impose a non-unity (i.e., not equal to 1.0) gain and non-zero offset to the video's luminance and chrominance levels. A luminance gain change is like adjusting a television's contrast knob while an offset change is like adjusting a television's brightness knob.

Note: The VQM software independently estimates the gain and offset for each of the three video component signals (luminance Y, blue chrominance C_B , and red chrominance C_R). However, gain and offset correction is only applied to the luminance Y component.

➤ **None**

No Gain/Offset calibration will be performed (i.e., the gains are assumed to be 1.0 and the offsets are assumed to be 0.0).

➤ **Estimate from Color Bar**

The VQM Software automatically calculates the Gain/Offset from the color bar in the TVS. If a test is being executed with a library containing both original and processed video clips, this option is disabled.

➤ **Use Last Value**

In the case the user has completed a previous test and wishes to use the same calibration results, the user may select "Use Last Value". This option is only recommended if the same HRC is being tested twice consecutively.

➤ **Manual**

The user will be presented with a screen to manually enter the Y gain and offset, C_B gain and offset, and C_R gain and offset. The default values are 1.0 for the gains and 0.0 for the offsets. All video clips are assumed to have the same Gain/Offset values.

➤ **Calculate for each clip**

The VQM Software automatically calculates the Gain/Offset for each clip that is in the library or TVS. When the Gain/Offset by clip is being calculated, a progress bar on the status bar is displayed.

3.3.2.5 Temporal Registration

Temporal Registration is the process by which the VQM Software determines the proper time alignment between the processed video clips and the original video clips. What is desired during this step is the best overall temporal shift for each clip pair that brings them into alignment. Temporal registration may be ambiguous (i.e., no single temporal shift can bring all frames into alignment) since some video systems have variable video delay (i.e., the delay through the video system can change depending upon scene content or network conditions) or output frames that contain portions of several original video frames. In most cases, the temporal filters used for the video quality models (section 3.5)

will tend to smooth over these differences and still produce accurate video quality predictions. Temporal Registration errors will normally result in predictions of video quality that are worse than expected.

The Temporal Registration process is also used in section 2.3.3. Note that if the user temporally registered a parent clip in the library, the individual children (sub-clips) must still be temporally registered at this time. If the video file is not parsed in the library (no child clips exist) but is temporally registered, then there is no need to perform Temporal Registration here (i.e., the user may select the None option).

➤ **None**

No Temporal Registration calibration will be performed.

➤ **Manual**

The user will be presented with a screen displaying the original and processed video one frame at a time. The user can then use the Next and Previous buttons to advance the video until they are aligned temporally. Either the original or processed video must be at the beginning of the clip in order for the alignment value to be valid.

➤ **Calculate for Each Clip (Sequence Based)**

The VQM Software automatically calculates the temporal registration for each clip pair using the sequence based algorithm. This is selected as the default for HRCs with an expected video quality of type Television.

➤ **Calculate for Each Clip (Frame Based)**

The VQM Software automatically calculates the temporal registration for each clip pair using the frame based algorithm. This option is selected by default for HRCs with an expected video quality of type Video Conferencing or Unknown.

3.3.2.6 Other Variables

➤ **Frequency**

Frequency specifies the frequency at which images are examined. Some calibration routines do not need to examine every image from each clip. Rather, the routine will examine one out of every Frequency images. A small value for Frequency may result in an unacceptably long run time. The default value for Frequency is equal to half of the frame rate, rounded down if necessary.

➤ **Uncertainty**

Uncertainty specifies the accuracy of the initial temporal registration (i.e., the actual temporal registration is assumed to lie within plus or minus the uncertainty, where the first image in each processed clip is assumed to be temporally registered to the first image in the associated original clip). Be sure to choose Uncertainty large enough to include all likely temporal registrations that might be present in the clip pairs. An Uncertainty of zero means that the clip pairs are perfectly temporally registered. The default value for Uncertainty is equal to the frame rate, rounded down if necessary.

3.4 Viewing Calibration Results

After calibration has been computed, a screen (see Figure 25) will appear that reports the Calibration Results. Included with the results are the methods of calibration that were used (section 3.3). Results are displayed for each clip pair for Temporal Valid Region, Processed Valid Region, and Temporal Registration. The Spatial Registration and Gain/Offset results are display for the HRC (only one set of values is allowed per HRC). Here the results for each clip pair have been combined to produce an overall estimate of Spatial Registration and Gain/Offset. When available, menu options are provided for the user to view the entire intermediate calibration results.

If satisfied with the Calibration Results, select the Next button to proceed with the selection of the video quality model (section 3.5).

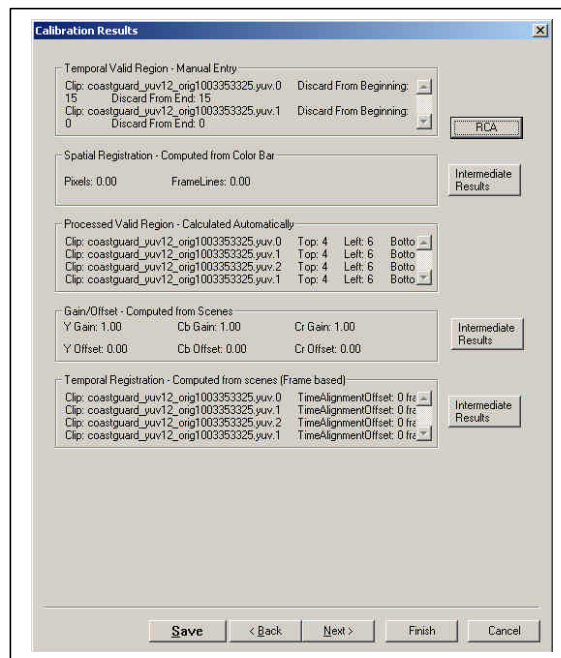


Figure 25. Calibration Results screen.

➤ RCA (Root Cause Analysis, Calibration)

If, during calibration, the software detects that the calibration values are outside of the normal range of expected values, you will be warned that there may be something extraordinarily wrong with the video system being tested. By pressing the RCA button, the user can determine exactly what calibration problems were detected and then decide whether or not to proceed with the test. This information is also presented in the report at the end of a test. Section 9.1 of NTIA Report 02-392 contains a detailed description of the Calibration RCA (see section 1.3).

➤ Intermediate Results

When calibration has been performed by means of an automated algorithm, the user has the option of examining more detailed results of the algorithm's performance. To access

any specific calibration report, press the Intermediate Results button adjacent to that calibration step.

3.5 Selecting the Video Quality Model

The Model Selection dialog box is shown in Figure 26. With this dialog box, the user will select the specific video quality model to use in the test, set a subjective scale and an associated pass/fail threshold, and (optionally) select to save intermediate video data for a selected video quality parameter.

When all model options have been specified, press the Next button and proceed to Selecting the Region of Interest (section 3.6).

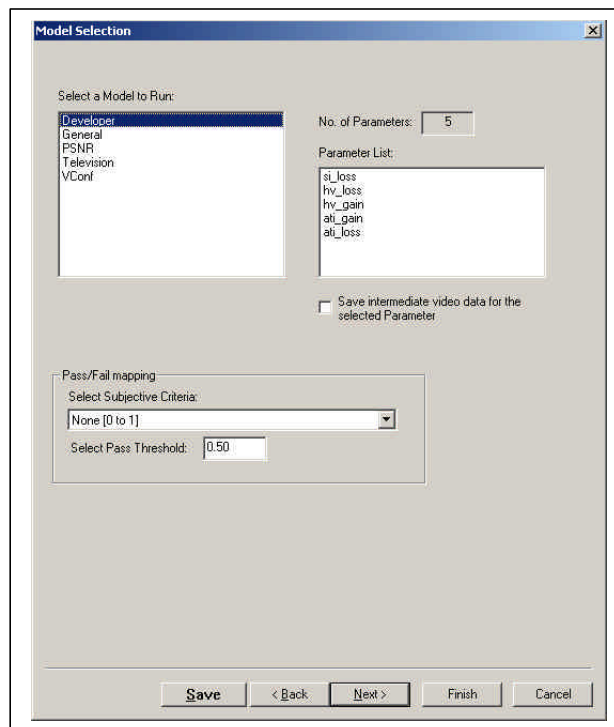


Figure 26. Model Selection dialog box.

3.5.1 Select a Model to Run

The user selects a video quality model that is appropriate for the application or HRC being tested. Five video quality models are provided with the VQM Software. These five models, fully described in section 6 of NTIA Report 02-392 (see section 1.3) are called:

1. General
2. Developer
3. PSNR
4. Videoconferencing
5. Television

The software module that computes the video quality model is multi-threaded and can utilize multiple CPUs if they are present in the PC where the VQM software is installed. To take advantage of this speed increase there must be more than one video clip pair in the test (each CPU will compute the selected video quality model for one clip pair at a time).

➤ **General**

The General Model provides a set of parameters and parameter weightings that allow the user to accurately evaluate video quality over a wide range of quality and bit rates. The user should expect processing at a rate of about 9 fps (typical PC configuration in Appendix A), assuming PC based video formats (CIF or QCIF).

➤ **Developer**

The Developer Model is a faster version of the General Model emphasizing processing speed at the cost of some accuracy. The user should expect processing at a rate of about 47 fps (typical PC configuration in Appendix A), assuming PC based video formats (CIF or QCIF).

➤ **PSNR**

The Peak Signal to Noise Ratio (PSNR) Model uses the traditional measurement of peak signal to noise and is most useful for video systems that exhibit noise-like impairments (e.g., bit rates > 1.5 Mbits/sec, analog broadcast, multi-generation tape duplications, etc.). PSNR can also be used to determine if any lossy compression has been performed on the original video. The user should expect processing at a rate of about 64 fps (typical PC configuration in Appendix A), assuming PC based video formats (CIF or QCIF) and about 4 fps for NTSC format.

Note: The PSNR calculation used by the VQM Software uses a value of 235 for the peak signal (rather than 255). In addition, PSNR model values are converted to the (0, 1) scale used by the VQM Software with a logistics function (see ANSI T1.801.03-1996, ATIS Technical Report T1.TR.74-2001, and NTIA Report 02-392 in section 1.3).

➤ **Videoconferencing**

Relative to the General Model, the Videoconferencing Model is specifically optimized for the lower video quality space found in most videoconferencing applications (bit rates from 10 kbits/sec to 1.5 Mbits/sec). The user should expect processing at a rate of about 12 fps (typical PC configuration in Appendix A), assuming PC based video formats (CIF or QCIF).

➤ **Television**

Relative to the General Model the Television Model is specifically optimized for the high video quality space found in television video (bit rates > 1.5 Mbits/sec). The user should expect processing at a rate of about 10 fps (typical PC configuration in Appendix A), assuming PC based video formats (CIF or QCIF) and about 1 fps for NTSC format.

3.5.2 Pass / Fail Mapping

This feature allows the user to select a specific Subjective Criteria (or scale) and a corresponding Pass Threshold for this scale.

➤ **Subjective Criteria**

The user can select a specific Subjective Criteria (or scale) that should be used. The native (0, 1) scale used by the VQM Software (0 being no impairment, and 1 being nominally the maximum impairment) will be mapped to this Subjective Criteria. Four Subjective Criteria are provided: (1) None (0 to 1), (2) Double Stimulus Impairment Scale (1 to 5, where 5 is no impairment), (3) Double Stimulus Continuous Quality (0 to 100, where 0 is no impairment), (4) Double Stimulus Comparison Scale (-3 to +3, where -3 means the processed is much worse than the original).

➤ **Pass Threshold**

The Pass Threshold allows the user to set a value (for the selected Subjective Criteria) at which the processed TVS is considered to pass the test (i.e., have sufficient quality required by the user).

3.5.3 Number of Parameters in Model and Parameter List

These fields are automatically updated to show the user the number of parameters in the selected video quality model and the names of those specific parameters. This field is not user-editable. Figure 26 shows the Developer Model's Parameter List. Note that different parameters and combinations of parameters exist for each video quality model.

3.5.4 Save Intermediate Video Data

The Save Intermediate Video Data check box allows the user to save filtered, feature-extracted, and parameter video sequences for a user-selected parameter in the Parameter List. This feature may be useful for root cause analysis (RCA) as explained in section 4.3. When this box is checked, a pull down menu appears. The user must then select one clip pair for which to save the Intermediate Video Data.

3.6 Selecting the Region of Interest

The user must now determine both the spatial and temporal region of interest (SROI and TROI, respectively) for the video quality model computation. The VQM will be performed only on that portion (spatially and temporally) of the clip selected in the ROI field. The smaller the SROI and TROI, the faster VQM will be computed. Figure 27 shows the Region of Interest dialog box.

SROI is a rectangular-shaped subset of the Processed Valid Region. The default SROI for NTSC corresponds to approximately that portion of the video picture that is visible on a television monitor, excluding the over-scan area. The user is not restricted to accepting the default settings and may set any SROI.

Temporal ROI is a specific time segment, sequence, or subset of frames that is used to calculate the clip's VQM. The TROI is a subset of the frames that lie completely inside the Temporal Valid Region. The maximum possible TROI is the fully registered time segment and contains all temporally registered frames within the TVR. The user is not restricted to accepting the default settings and may set any TROI.

When you are satisfied with the SROI and TROI settings for all video clips, press the Next button to continue with the test. The VQM Software automatically computes the selected video quality model for the processed TVS based on the subjective mapping that was selected. Computation time will vary in duration based on both the number and the duration of the video clips, and the number of CPU's in the user's PC. When model calculations complete, the test results screen will be displayed (see section 4). The user may want to save the test at this time.

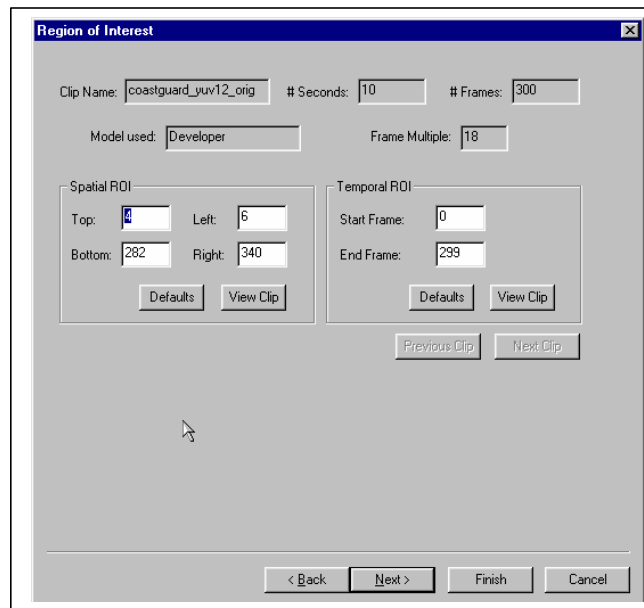


Figure 27. Region of Interest dialog box.

➤ **Clip Name**

The current clip whose SROI and TROI are being modified will appear in this field. This is not a user-editable field.

➤ **Duration and Number of Frames**

The duration and number of frames existing in the clip will appear in these fields. These are not user-editable fields.

➤ **Spatial ROI**

The user may either enter the SROI numerically using the fields provided or select View Clip and set the SROI graphically by using the mouse to move the blue dashed lines. The Defaults button will reset the values to the initial default value.

➤ **Temporal ROI**

The user may either enter the TROI numerically using the fields provided or select View Clip and set the TROI graphically. The TROI appears re-numbered after the calibration process (temporal registration). The 0 frame now indicates the first frame in the newly calibrated clip. The VQM Software will automatically adjust the TROI to at least 3x the frame multiple of the selected video quality model (i.e., the frame multiple is the largest temporal duration of the spatial-temporal blocks used for any of the parameters in the

selected video quality model, see section 4.1.2 of NTIA Report 02-392) and report that adjustment to the user. If the number of frames in the TROI is not an exact integer multiplication factor of the frame multiple shown in the box, the VQM Software will automatically adjust the TROI (when the Previous Clip or Next Clip button is selected) to the nearest frame multiple by truncating frames off the end of the video clip. This truncation could result in a video clip duration of less than four seconds (the minimum allowed) and as a result the user will not be able to continue past the ROI screen. Thus, it is highly recommended that the user start with video clips that are at least five seconds long when creating a library.

➤ **Previous Clip and Next Clip**

Previous Clip and Next Clip allow the user to increment through the selected clips in the library and set the SROI and TROI for each clip. Note the user needs to set the TROI and SROI for each clip since modifying the settings of one clip does not automatically modify every clip in the test.

4. TEST RESULTS

This Test Results screen (see Figure 28) provides access to a variety of tools, screens, plots, and reports that summarize the measured video quality of the processed video. The example displayed in Figure 28 shows the results for a test using the video conferencing model.

The general philosophy of results presentation is that very high level results (e.g., HRC VQM, Pass / Fail result) are presented to the user first, with successively more detailed results becoming accessible as the user ventures deeper into the menu system. Thus, at the highest level HRC VQM is available while at the next level Clip VQM becomes available, while at still the next level, individual quality parameter results become available. This hierarchical arrangement enables the user to access only the amount of detailed results that is desired, with the remainder being hidden from view.

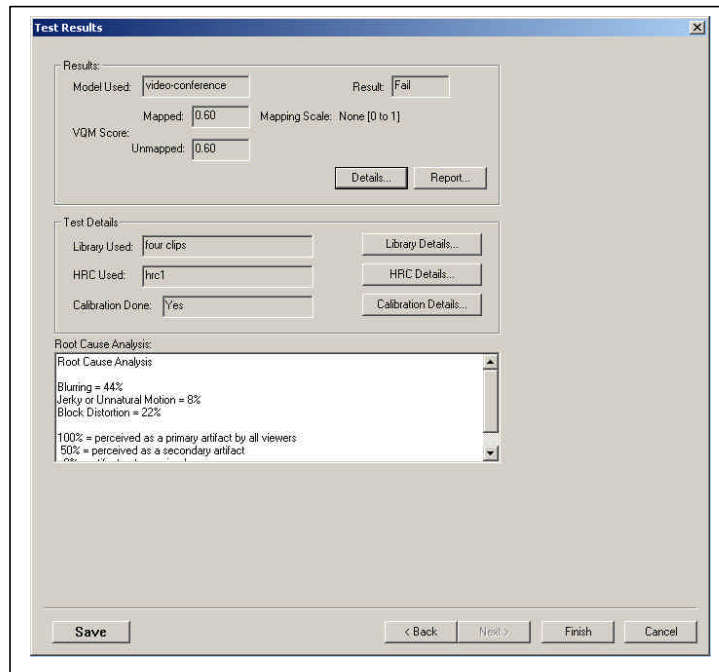


Figure 28. Test Results screen.

4.1 Results

4.1.1 High Level Summary Results

➤ Model Used

This field gives the video quality model that was selected in section 3.5.

➤ VQM Score

This field provides the user with the average HRC VQM of all the processed video clips in the test. This information is provided in three forms: the mapped subjective scale (see section 3.5.2), the unmapped or native (0, 1) subjective scale, and (if available, not shown in Figure 28) the raw parameter value before translation to the native (0, 1) subjective scale (e.g., PSNR values are also displayed in raw dB, which are limited to 130 dB in the VQM Software to prevent taking the logarithm of zero).

➤ Result

This field provides the result of the Pass/Fail Threshold (see section 3.5.2)

4.1.2 VQM Score Details

Selecting Details provides the user with the VQM Score Details screen shown in Figure 29. This screen provides a plot of the Pass / Fail Threshold (the dashed blue line) and the VQM of each individual clip (i.e., Clip VQM, the bar chart). Figure 29 shows results displayed using the native (0, 1) VQM Software's video quality scale. The screen also provides a text boxes that display the HRC VQM. From the VQM Score Details screen,

the user may continue probing for more detailed results as described below (section 4.1.2.1) or press Close to return to the Test Results screen (Figure 28).

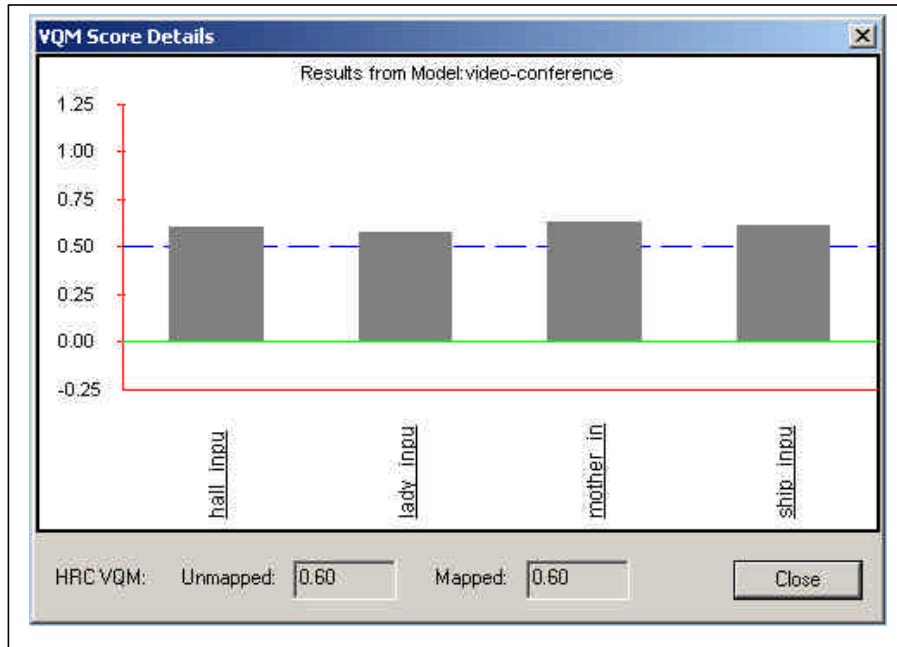


Figure 29. VQM Score Details screen.

4.1.2.1 VQM Details per Clip

Positioning the mouse over a specific clip name in the VQM Score Details screen and clicking the left hand mouse button will produce the VQM Details per Clip screen shown in Figure 30. This screen provides the user with a summary of the video quality information for that individual video clip. This information includes the Clip Name, HRC VQM Score, Pass / Fail Result, SROI, TROI, and impairment Root Cause Analysis specific to the video clip (also see section 4.3). The plot displays the Pass / Fail Threshold (the dashed blue line), and the individual Clip VQMs (the bar chart). Figure 30 shows results displayed using the native (0, 1) VQM Software's video quality scale. The contribution of each parameter to the Clip VQM can be obtained from this screen. For the native (0, 1) subjective scale, positive deviations from zero (zero is plotted with a solid green line) denote quality degradations while negative deviations from zero represent quality improvements (i.e., the video quality model that is selected may utilize objective parameters that detect quality improvements as demonstrated in Figure 30). When completed with this screen, the user may continue probing for more detailed results as described below (section 4.1.2.2) or press Close to return to the VQM Score Details screen (Figure 29).

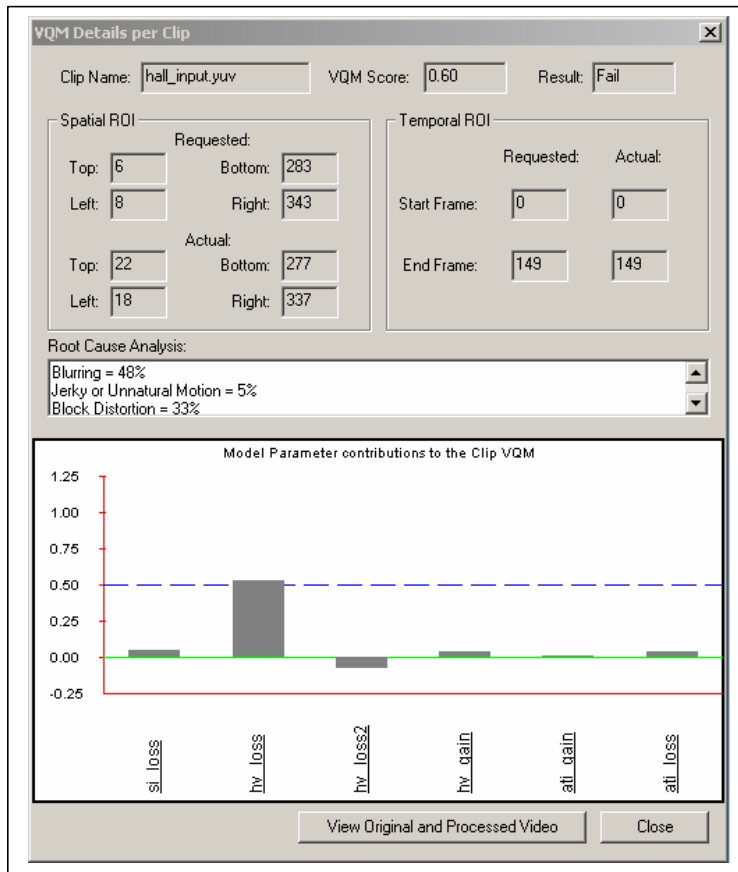


Figure 30. VQM Details per Clip screen.

➤ **View Original and Processed Video**

The user may view the original and processed video for the clip by selecting this button.

4.1.2.2 Parameter Time History

Positioning the mouse over a specific video quality parameter name in the VQM Details per Clip screen and clicking the left hand mouse button will produce the Parameter Time History screen shown Figure 31. This screen provides the user with a plot of the selected parameter time history. Information on this screen includes the Parameter Name, Clip Name, Technical Name of the parameter, and a plot of the parameter value as a function of each frame in the clip, where parameter values have been scaled to the native (0, 1) VQM subjective scale. This plot can provide insights as to *when* (temporally) in the clip the contributing artifact or impairment occurred. From this screen, the user may continue probing for more detailed results as described below (section 4.1.2.3) or press Close to return to the VQM Details per Clip screen (Figure 30).

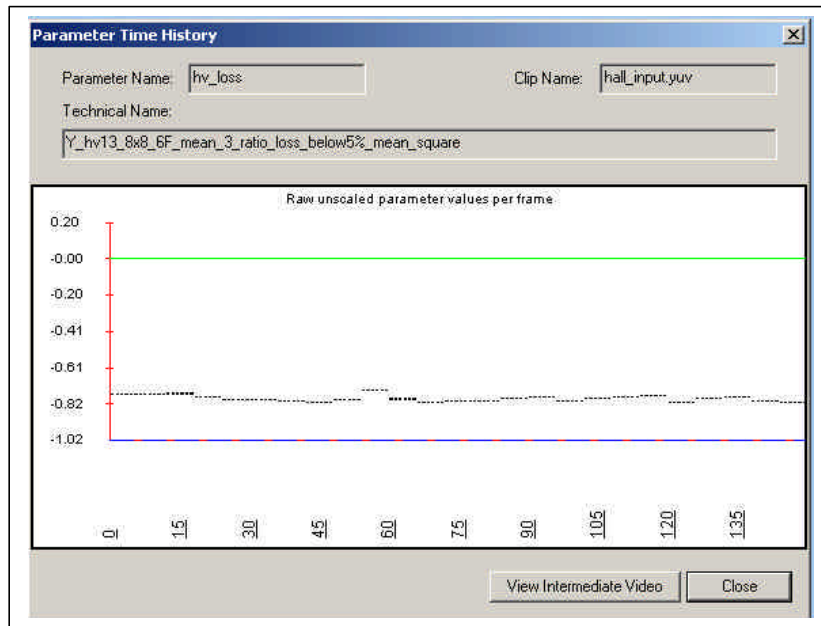


Figure 31. Parameter Time History screen.

4.1.2.3 **Save Intermediate Data**

Clicking on the View Intermediate Video button in the Parameter Time History Screen (Figure 31) will produce the Save Intermediate Data screen shown in Figure 32. This screen allows the user to save and view the perceptually filtered video, the feature-extracted video, and the parameter video for the selected clip pair and video quality parameter. This feature is useful for determining the spatial and temporal locations of specific video impairments or artifacts.

The five video Types that can be examined with this screen are:

- Filtered Original - the original video sequence after parameter-specific perceptual filtering.
- Filtered Processed - the processed video sequence after parameter-specific perceptual filtering.
- Feature Original - the Filtered Original video sequence after parameter-specific feature extraction.
- Feature Processed - the Filtered Processed video sequence after parameter-specific feature extraction.
- Parameter - the parameter video obtained by comparing the Feature Original and Feature Processed video streams before any spatial or temporal error pooling. This video sequence may indicate the spatial-temporal portions in the video sequence that is most responsible for impairments detected by this parameter. Normally, white areas indicate larger parameter values and black areas contain smaller parameter values.

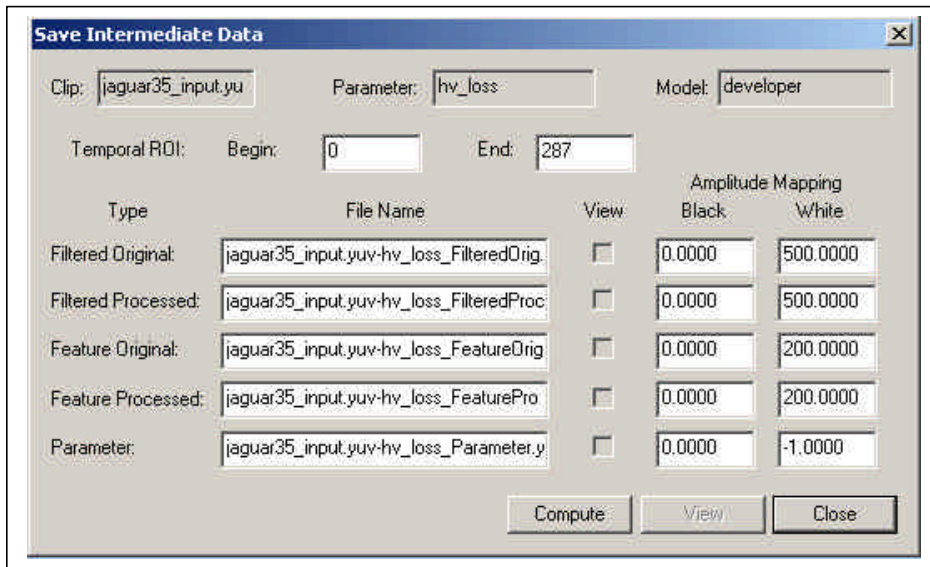


Figure 32. Save Intermediate Data screen.

➤ **Clip**

This field gives the name of the video clip being examined (not user-editable).

➤ **Parameter**

This field gives the name of the quality parameter for the video clip being examined (not user-editable).

➤ **Model**

This field gives the name of the video quality model being used (not user-editable).

➤ **Temporal ROI**

The temporal ROI specified by these boxes is used to compute the Filtered, Feature, and Parameter video streams. If the user is aware of the temporal location of the artifacts (from observing the parameter time history plots in Figure 31), then computational time can be reduced by reducing the temporal ROI to only those video frames that contain the artifacts. After the intermediate images have been computed, the Temporal ROI fields cannot be changed.

➤ **File Name**

The video sequence will be saved (temporarily) to the specified file name. Default file names are provided for all five intermediate video types. After the intermediate images have been computed, the file name fields cannot be changed.

➤ **View Checkboxes**

The View checkboxes are only available after the intermediate images have been computed. The View check boxes are used to specify the video sequences to be viewed when the View button is pressed. **A maximum of two boxes may be simultaneously checked for side-by-side viewing of two intermediate video streams.** After viewing the first two types, the user may return to this screen and select two more video types to view. If the user specified the computation of intermediate video for this video clip and parameter during video quality model selection (see section 3.5.4), then the intermediate

images will already have been computed. In this case, the pre-computed intermediate images are immediately available for viewing by the user.

➤ **Amplitude Mapping**

The Filtered, Feature, and Parameter images are floating point numbers that must be mapped to 8-bit gray shade or 24-bit color display. The Black and White boxes allow the user to input the floating point numbers used to perform this linear mapping. Video at the Black threshold is scaled to 1 while video at the White threshold is scaled to 254, with values outside of these ranges being clipped (1 and 254 is used since 0 and 255 are reserved for synchronization data in ITU-R Recommendation BT.601 – see reference in section 1.3). After the intermediate images have been computed, the Black and White fields cannot be changed.

➤ **Compute**

When the Compute button is pressed, the intermediate video data are calculated and stored to disk, according to the options specified above. Once this has been done, the user must exit the Save Intermediate Data screen (Figure 32) before the new intermediate images can be recalculated with a different temporal ROI, amplitude mappings, and file names.

➤ **View**

After the intermediate video data has been calculated, the View button becomes active. When this button is pressed, the intermediate video is displayed in a popup window.

➤ **Close**

Press the close button to return to the Parameter Time History screen (Figure 31). If intermediate images have been calculated and stored to disk, the user will be given the option to save or erase them.

4.1.3 Report

The Report button on the Test Results Screen (Figure 28) provides the user with a scrollable window with a summary of all the test data. The Summary Report option (Figure 33) contains a brief summary of the test results. The Detailed Report option (not shown) contains a lengthy report of all the test results. The user may view the report, print the report, or save the report either as a text file or a Microsoft Excel® readable table. To save a Detailed Report that will later be viewed in Excel, select the Save As Type drop down box on the Save As Type popup screen and select the 'Excel importable CSV file (*.csv)' option. Then launch Microsoft Excel and open the CVS file you just saved.

Note: The Excel file is the only place where the parameter time history data is included.

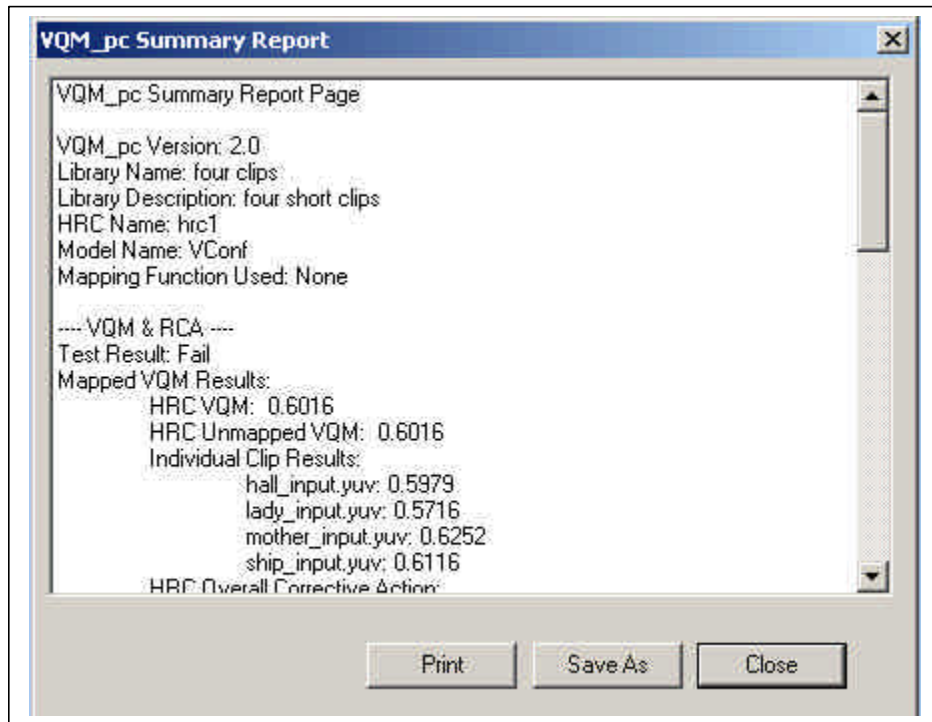


Figure 33. Summary Report screen.

4.2 Test Details

➤ Library Used

This field reports the library that was used in the test. The user may select the Library Details button for more information.

➤ HRC Used

This field reports the HRC information that was used for the test. Remember, it is the user's responsibility to ensure that the HRC information matches the actual HRC that was used during the test. The user may select the HRC Details button for more information.

➤ Calibration Done

This field reports if calibration was performed during the test. If a calibration was performed, a Calibration Details button is available that will provide detailed calibration results.

4.3 Root Cause Analysis (Impairment)

The root cause analysis (RCA) window provides information to the user on potential artifacts, or impairments that may have contributed to the HRC VQM. HRC RCA differs from the Clip RCA (as shown in Figure 30) in that all of the clips in the test are examined for impairments. Impairment RCA provides mappings from the objective video quality parameters to specific types of video impairments. These mappings are fully described in section 9.2 of NTIA Report 02-392 (see section 1.3). The type of impairment RCA that is available depends upon the particular video quality model and the parameters that

comprise that model. The percentages associated with the perception of specific artifacts were estimated from subjective experiments. 100% means that the artifact was perceived as being the primary artifact by all the viewers, 50% means that the artifact was perceived as being a secondary artifact, and 0% means that the artifact was not perceived.

The user should utilize the RCA fields (Figure 28 and Figure 30), as well as parameter time histories (Figure 31), and intermediate video (Figure 32) to fully understand the impact of individual artifacts and impairments on Clip VQM and HRC VQM.

5. TOOLS

The main **Tools** menu is shown in Figure 34. Tools are available for capturing AVI clips and converting them into the native UYVY Raw Video format used by the VQM Software (Capture Video – section 5.1, AVI to Raw Video Converter – section 5.2, RAW Video to UYVY Converter – section 5.3). Video files in UYVY Raw Video format can also be converted into AVI files (UYVY to AVI Converter – section 5.4). The user may play AVI files (AVI Player – section 5.5) and UYVY files (UYVY Player – section 5.6), edit UYVY files (UYVY Editor – section 5.7), and down sample UYVY files (Frame Size Down Sampler – section 5.8).

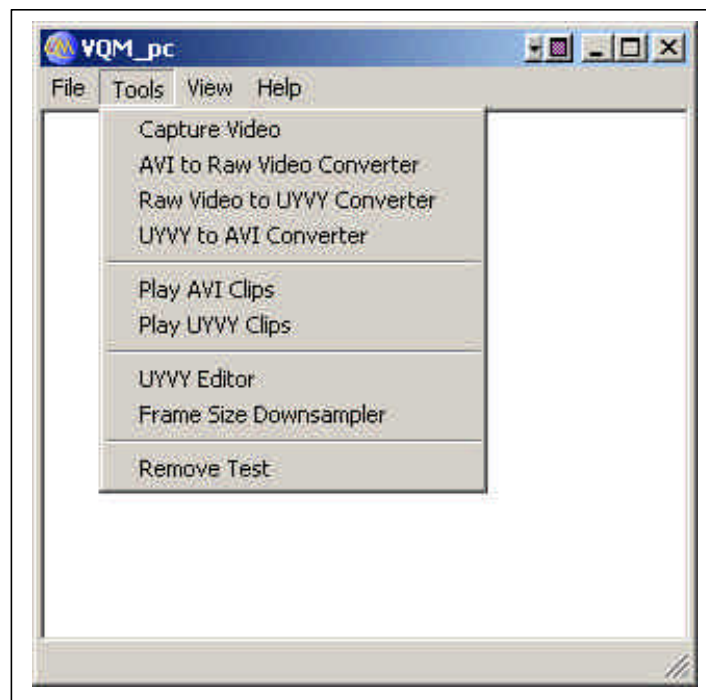


Figure 34. The VQM Software's main screen showing the **Tools** sub-menus.

5.1 Capture Video

The Capture Video feature allows the user to capture video from an external source such as a CE hardware device (or any other HRC) and store the data directly to your hard disk

as an AVI file. The Capture Video feature is useful for capturing new original clips for video libraries, capturing corresponding processed video clips from HRCs, or capturing a processed TVS (see section 3.2). While this feature was originally developed and tested using an SGI-540 Workstation that has real time uncompressed video capture hardware (see Appendix A), any Windows-compatible capture device can be employed that provides the user with the required video quality level. The user is cautioned to use a high performance PC, capture card, and disk drive to ensure high quality capture (i.e., no dropped frames, etc.) so as not to degrade the quality of the processed video. Direct X Media 8.0 must be installed on the capture PC for this feature to function. Figure 35 shows the Capture Video screen.

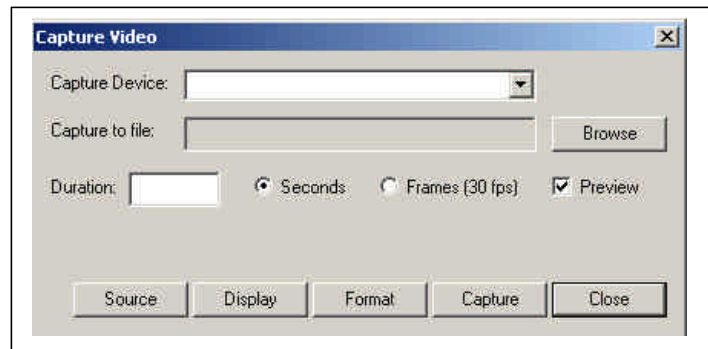


Figure 35. Capture Video screen.

➤ **Capture Device**

Assuming the user has a capture card and capture drivers, the VQM Software will automatically detect the driver(s) and load as many drivers as are found.

➤ **Capture to File**

The user must provide a name for the file that will be used to store the captured video. The VQM Software will pre-allocate disk space before beginning capture. This is necessary to assure a smooth capture with no dropped video frames (provided the specified file can handle the required data storage rate).

➤ **Duration**

The user must select either “Seconds” or “Frames” and then enter the duration in seconds or frames, respectively.

➤ **Source, Display, and Format**

Depending upon the capture driver employed, the VQM Software will provide various options for setting the video source, display, and format.

➤ **Capture**

When the Capture button is pushed, the VQM Software will pre-allocate disk space and then prompt the user to begin the capture.

5.2 AVI to Raw Video Converter

This tool allows the user to convert AVI files into raw video files (see section 1.2 for a definition of Raw Video). AVI files must be converted into raw video files before they

can be converted into the UYVY format using the Raw Video to UYVY Converter tool (section 5.3). Figure 36 shows the screen for the AVI to Raw Video Converter tool.

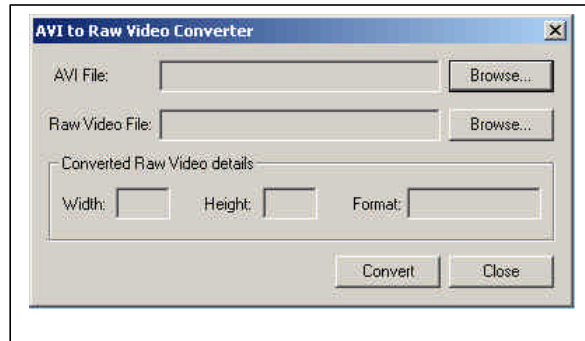


Figure 36. AVI to Raw Video Converter screen.

➤ **AVI File**

The user enters the name of the AVI file to be converted.

➤ **Raw Video File**

The user enters the name of the resulting raw video file (extension is not important).

➤ **Converted Raw Video Details**

This field provides the user with the frame size and format of the converted raw video file. This is not a user-editable field but the user should write this information down as it will be required as input by the Raw Video to UYVY Converter tool (section 5.3).

5.3 Raw Video to UYVY Converter

This tool provides capability to convert raw YUV12, YUY2, and RGB24 video formats as output by the AVI to Raw Video Converter tool in section 5.2 (see section 1.2 for a definition of Raw Video) into the VQM Software's native raw UYVY video format. All video files must eventually be in UYVY format before the VQM Software can perform video quality measurements. Figure 37 illustrates the screen for this tool.

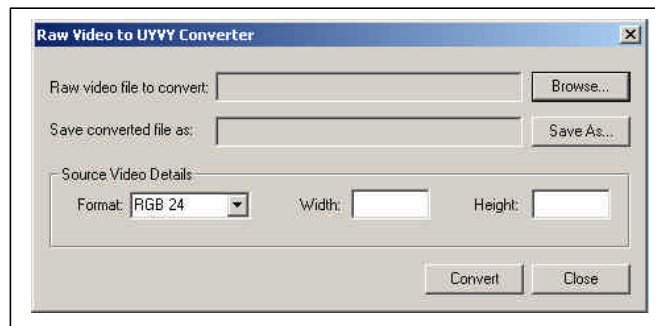


Figure 37. Convert Raw Video to UYVY screen.

➤ **Raw File to Convert**

The user browses for the raw video file to convert.

➤ **Save Converted File As**

The user must enter a file name including the .yuv extension for the resulting UYVY file.

SOURCE VIDEO DETAILS

➤ **Format**

Current formats that can be converted by the VQM Software include YUV12, YUY2 and RGB24.

➤ **Width and Height**

The user must enter the width and height (in pixels) of the video frames in the File to Convert.

5.4 UYVY to AVI Converter

This tool allows the user to convert UYVY files into AVI format (see Section 5.5). Figure 38 shows the screen for this tool.

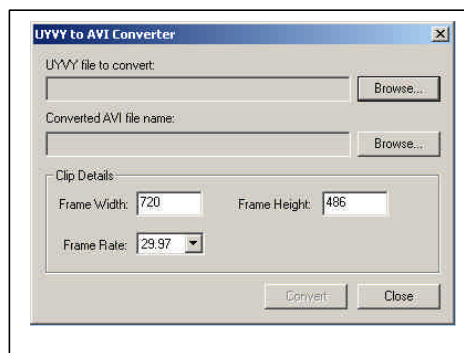


Figure 38. UYVY to AVI Converter screen.

➤ **UYVY File to Convert**

The user enters the UYVY file that will be converted to AVI format.

➤ **Converted AVI Filename**

The user enters the new AVI file name.

➤ **Clip Details**

The user must enter the correct Frame Width, Frame Height, and Frame Rate.

5.5 AVI Player

The VQM Software provides the capability for the user to play an AVI file. This tool is only valid for systems supporting the UYVY AVI format (e.g., Silicon Graphics SGI-540™ Visual Workstation or other video systems that support ITU-R Recommendation BT.601 – see section 1.3 and Appendix A). Note that Direct X Media 8.0 is required on the capture system for this tool to function.

5.6 UYVY Player

The UYVY Player (Figure 39) enables the user to play UYVY formatted clips, which is the native video format for the VQM software. Any file in the UYVY format (with a .yuv extension) can be played using this tool. The UYVY player is accessible from a number of screens throughout the VQM Software (anywhere the user is allowed to view a video clip). When selecting the UYVY Player, the user will be prompted with a dialog box (not shown) that will ask the user for the file name, frame width, frame height, and frame rate. This information is required to play the UYVY files correctly since the UYVY format is a Raw Video file format that does not contain any header information.

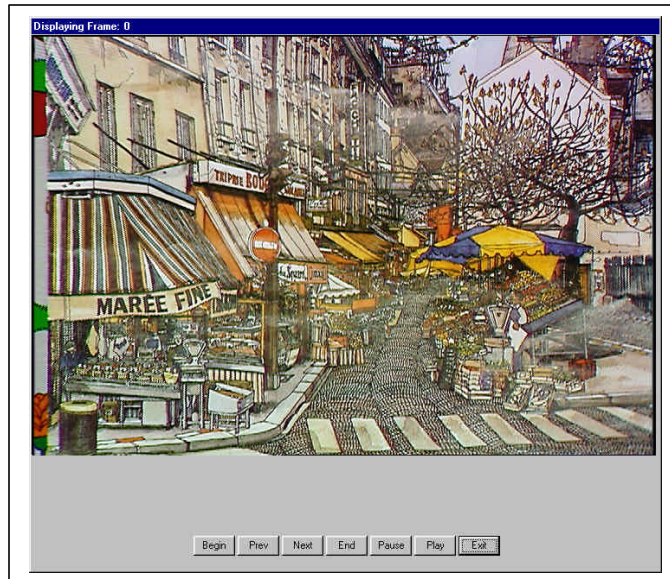


Figure 39. UYVY Player screen.

5.7 UYVY Editor

The UYVY Editor allows the user to edit existing UYVY clips by either repeating or removing frames. Figure 40 shows the screen for the UYVY Editor.

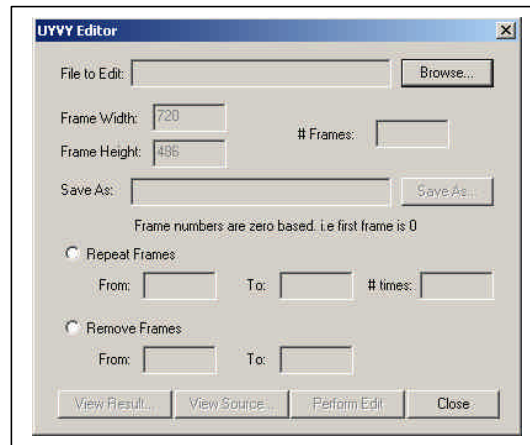


Figure 40. UYVY Editor screen.

➤ **File to Edit**

The user first enters the source UYVY file to edit. The rest of the dialog inputs are deactivated until the user enters a File to Edit.

➤ **Frame Width, Frame Height**

The user enters the Frame Width and Frame Height (default values are 720 and 486). The VQM Software will calculate the number of frames.

➤ **Save As**

The user enters the new file name to save the edited UYVY result.

➤ **Repeat Frames, Remove Frames**

The user must select whether repeating frames or removing frames is desired. When repeating frames, the user specifies the range of frames to be repeated and the number of times this range of frames is to be repeated. When removing frames, the user specifies the range of frames to be removed.

➤ **View Result, View Source**

These options allow the user to view the UYVY source or edited result.

➤ **Perform Edit**

This button performs the actual edit.

5.8 Frame Size Down Sampler

This tool allows the user to reduce the frame size of a UYVY Raw Video file. Note that this is not a lossless process and as such the user should apply caution. The user is strongly cautioned against down sampling the supplied color bars (see sections 2.2 and 3.1) for creation of new color bars as the down sampling filtering process may distort the special spatial registration patterns. Figure 41 shows the screen for this tool.

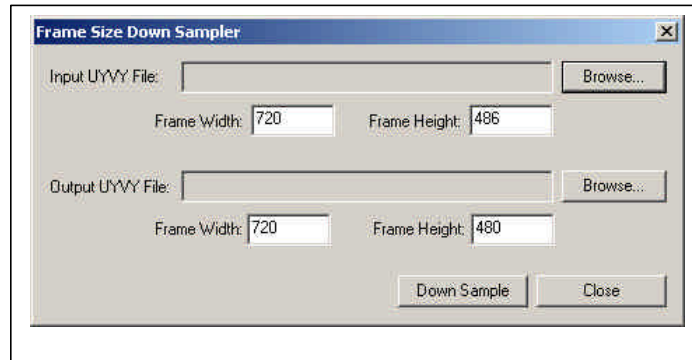


Figure 41. Frame Size Down Sampler screen.

➤ **Input UYVY File**

The user enters the name of the UYVY file to be down sampled.

➤ **Output UYVY File**

The user enters the name of the resulting UYVY file.

➤ **Frame Width, Frame Height**

The user must enter the Frame Width and Frame Height of the Input and the Output UYVY File.

➤ **Down Sample**

This button performs the actual down sampling.

5.9 Remove Test

By selecting **Tools – Remove Test**, the user may delete all of the test files (*.tst), data files (*.data), and video files (*.yuv files, e.g., Original TVS, Processed TVS, and intermediate video) that were created during a test.

APPENDIX A: SYSTEM REQUIREMENTS

TYPICAL PERSONAL COMPUTER CONFIGURATION

The typical PC used to test the VQM Software had the following specifications:

| Component | Specification |
|------------------|---|
| Operating System | Windows 2000 |
| Processor | Pentium 4, 1.4 GHz |
| RAM | 128 MB, 256-512 MB recommended |
| Video Card | Direct AGP 3D Graphics, 11MB video memory |
| Hard Drive | Ultra DMA, 20 GB |

SILICON GRAPHICS SGI-540 VISUAL WORKSTATION

The PC used to test uncompressed video capture had the following specifications:

| System Description |
|--|
| Silicon Graphics 540 Base Model |
| Quad Pentium ® III Xeon™ CPUs 550 MHz |
| 512 KB L2 Cache |
| 512 MB ECC |
| 9.1 GB ULTRA2 SCSI 10k RPM |
| Two 18 GB ULTRA2 SCSI 10k RPM (slaved volume) |
| Single Channel ULTRA2 SCSI Controller (PCI-64) |
| Windows ® NT Workstation 4.0 |
| SDI 1100 Serial Digital Video Interface Board |
| 32X Max EIDE |
| SGI Graphics/DMEDIA for NT 4.0 |