

Qdeo Video Processing

The World as YOU See It



▶ THE WORLD AS YOU SEE IT

In the past, video entertainment was a significantly constrained activity both in terms of content and medium. Traditionally, consumer video sources were limited to broadcast, cable, satellite and packaged media such as VHS and DVD and consumers were used to watching them in specific settings only, namely the traditional TV set in the family room or bedroom.

Over the last several years, dramatic improvements in technology have brought about a revolution in consumer entertainment. The sources and formats of video have expanded dramatically (as illustrated in Figure 1). At the same time there has been an explosion in the types of devices available for video entertainment, ranging from smart phones and portable media players, mobile internet devices (MID), connected digital photo frames and netbooks, all the way up to large flat panel displays and projectors. Various sources of video content have sought to optimize their content for specific viewing experiences, for example on cellphone or netbook screens, but today's sophisticated, always-on-the-go consumer is clearly looking to consume video entertainment on their terms – watching what they want, where they want it, when they want it. As illustrated in Figure 2, each consumer wants a customized experience that best fits their lifestyle – watching TV shows on their MID in the train, YouTube with their friends on their large-screen TV at home and so on. They expect the CE industry to tell them they can deliver “The World as YOU See It.”

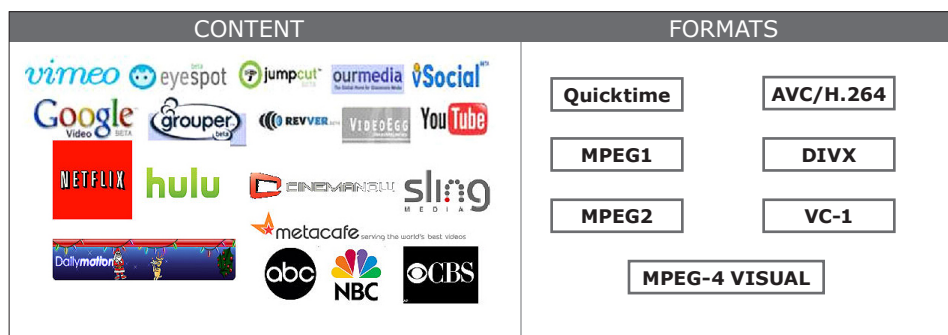


Figure 1: The World as YOU See It: Huge and rapidly growing universe of video sources and formats

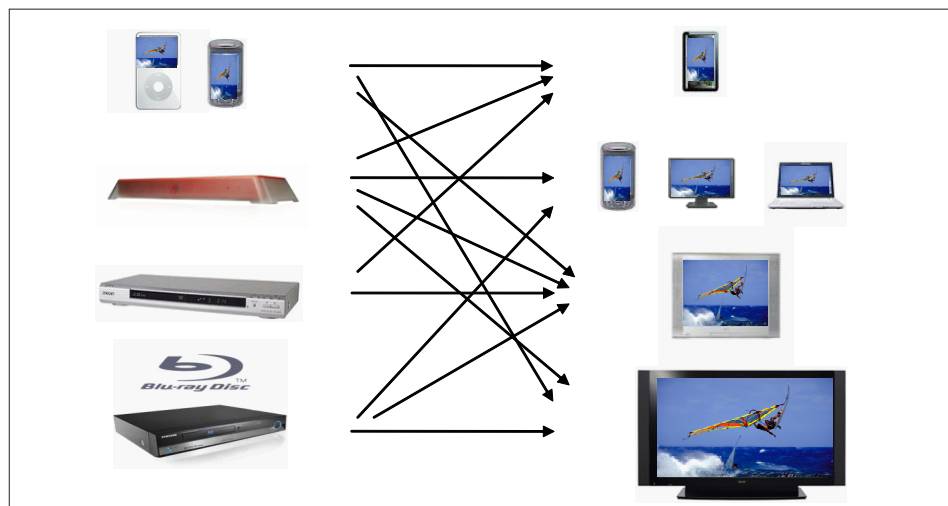


Figure 2: The World as YOU See It: Viewing whatever you want wherever you want

There are significant technical challenges in delivering on this vision. The fundamental attributes and quality of video varies greatly across the ocean of content that is becoming available – ranging from tiny cellphone video and amateur YouTube clips, professional download video such as iTunes, streaming video with variable bit-rates and resolutions from sources like Netflix, noisy legacy analog cable, digital SD and HD cable, satellite and broadcast where bit-rates and resolutions vary from show to show and channel to channel, all the way to pristine HD Blu-ray. At the same time, the consumers's expectations have been raised significantly because of the proliferation of high-resolution, high-quality displays of all sizes. Display resolution and quality has been going up at a rapid rate in all forms of devices. This offers the possibility of providing a compelling media experience on any device of the consumer's choice but it also means the consumer has a heightened awareness of good image quality and can easily be disappointed when their expectations are not met.

Delivering on the consumers' expectation of "The World as YOU See It" puts a heavy burden on the video processing that goes into the various video electronics devices. The video processing has to adapt to a very diverse and growing set of video content and formats – many different codecs, many different resolutions and frame-rates, and many types of artifacts.

▶ THE SOLUTION – QDEO™ VIDEO PROCESSING

Marvell developed Qdeo video processing in response to this unmet need. Qdeo refers to a suite of QuietVideo™ processing technologies that produce quiet and natural images free from noise and artifacts [1].

Qdeo video processing delivers "The World as YOU See It" through its unique adaptivity. The algorithms in this suite of technology operate on a per-pixel basis. The content is analyzed and the best possible decision is made at every pixel based on what is happening locally and globally. This unique combination of local and global information allows the algorithms to be effective at the broad range of resolutions that might be required – from QCIF all the way to 4K x 2K and beyond.

Qdeo video processing can be classified into three main stages:

- 1.Noise Reduction
- 2.Format Conversion
- 3.Enhancement

The underlying philosophy behind these three stages is that the noise and contamination in the video source needs to be removed before any further processing is done, then the content is converted to the desired resolution and finally various types of enhancements are applied to make the image more pleasing.

Each of these stages is explained in more detail below. The recently launched "Qdeo HD Video Evaluation" Blu-ray Disk provides good examples of the various types of processing described in the next sections [2].



Figure 3: Qdeo Video Noise Reduction (VNR)

Qdeo Noise Reduction

Most video material contains analog and/or digital noise. Noise Reduction refers to the process of reducing this noise while minimizing any side-effects.

Analog noise comes in the form of additive white Gaussian noise. It appears in the form of flickering dots that are most visible on smooth backgrounds such as a blue sky or a non textured wall. Qdeo technology uses 3D per-pixel motion-adaptive **Video Noise Reduction (VNR)** to completely remove the flickering dots from the stationary background and reduce the amount in moving areas without causing side-effects like blurring, ghosting (double imaging) or loss of detail. Figure 3 shows the results of applying Qdeo VNR.

Digital noise comes from compression of the video and appears in the form of "block noise" – small distinct rectangular tiles that are most visible on smooth backgrounds such as the sky or plain walls or floors and "mosquito noise" – tiny white dots that appear around sharp edges. Qdeo technology uses per-pixel content-adaptive **Compression Artifact Reduction (CAR)** to remove the block and mosquito noise without causing side-effects like blurring or loss of detail. Figure 4 shows the results of applying Qdeo CAR.



Figure 4: Qdeo Compression Artifact Reduction (CAR)

Qdeo Format Conversion

Most video material needs to be converted from its original resolution to match the native resolution of the display. Format conversion refers to the process of doing this conversion and comprises of de-interlacing and scaling.

Qdeo de-interlacing uses 3D per-pixel motion and edge adaptive de-interlacing to produce full-resolution in regions where there is no motion and smooth and clean edges for moving objects.

Qdeo **Vector Interpolation** calculates the direction of the edge to interpolate in that direction, thereby rendering a smooth image without objectionable jagged edges. In Figure 5, the left image shows the jaggies that are introduced along moving angled edges for conventional processing, while the right image shows the smooth clean edges that are produced by Qdeo Vector Interpolation.

Qdeo **Film Mode** does inverse telecine of the film-originated material by identifying the correct film cadence and weaving together the appropriate fields. If the de-interlacer is not able to detect and invert the film cadence, the output will show loss of vertical resolution and wavy interference patterns called Moire' in detailed regions like textured walls and radiator grills of moving vehicles. In Figure 6, the left image shows Moire' that is produced by

conventional processing when it fails to detect film cadence, while the right image shows the clean full-resolution image that results from Qdeo Film Mode. In addition, Qdeo de-interlacing is able to correctly identify video and film material when they are mixed together, as sometimes occurs during Television broadcasts, and handles the content appropriately to avoid the introduction of feathering artifacts in the video content.

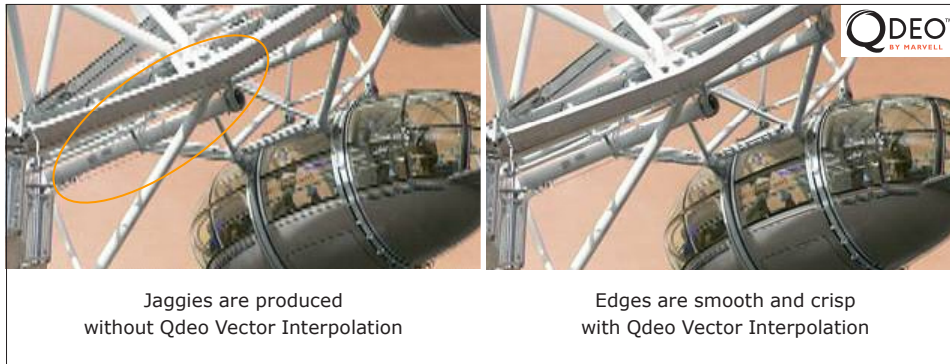


Figure 5: Qdeo De-interlacing: Vector Interpolation

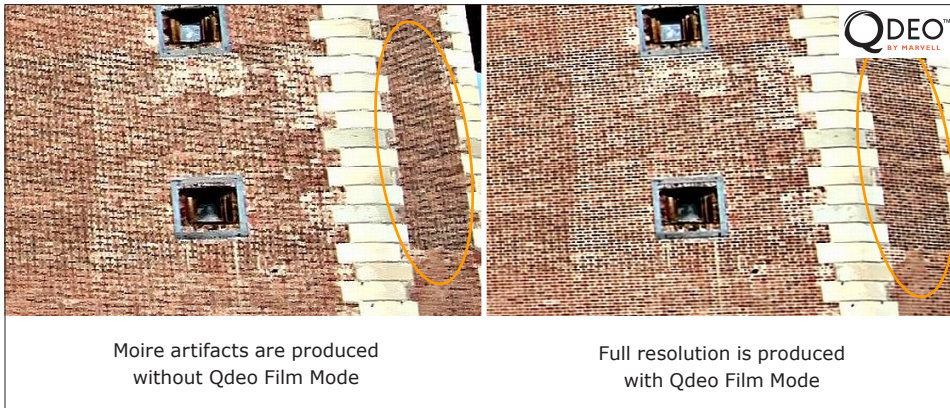


Figure 6: Qdeo De-interlacing: Film cadence detection and inversion

Qdeo Enhancement

Enhancement refers to the process of enhancing the appearance of the image by improving the contrast, bringing out the detail, making the colors more vivid, and creating a greater sense of depth. These enhancements can be done once the inherent noise is removed and the image has been converted to the desired display format.

Qdeo Enhancement includes Adaptive Contrast Enhancement (ACE), Intelligent Color Remapping (ICR), Natural Depth Expansion (NDE) and Bit Resolution Expansion.

Adaptive Contrast Enhancement (ACE) expands details in the shadows without crushing the mid-tones or highlights [3]. Figure 7 shows the result of applying Qdeo ACE.

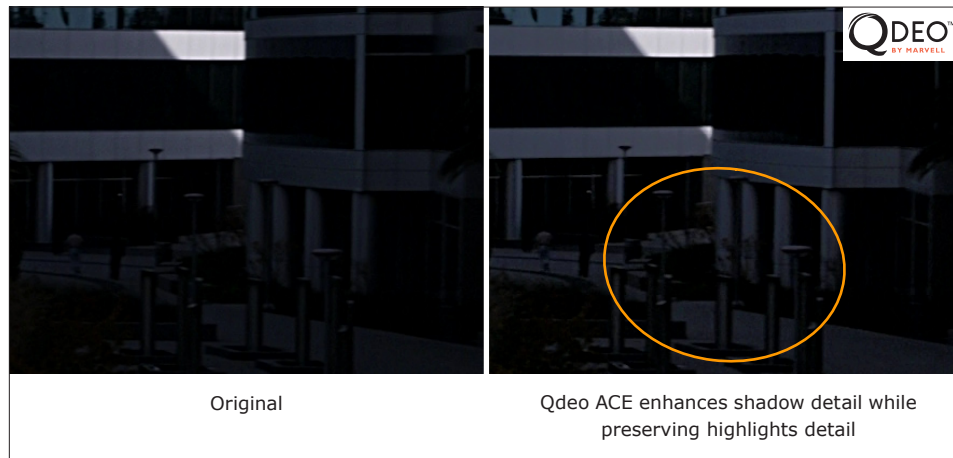


Figure 7: Qdeo Adaptive Contrast Enhancement (ACE)

Intelligent Color Remapping (ICR) enables vivid colors in outdoor scenes without causing hue shifts or loss of detail or changes in skin tones. It provides the ability to enhance certain colors in the spectrum while leaving other colors untouched. Figure 8 shows the result of applying Qdeo ICR.

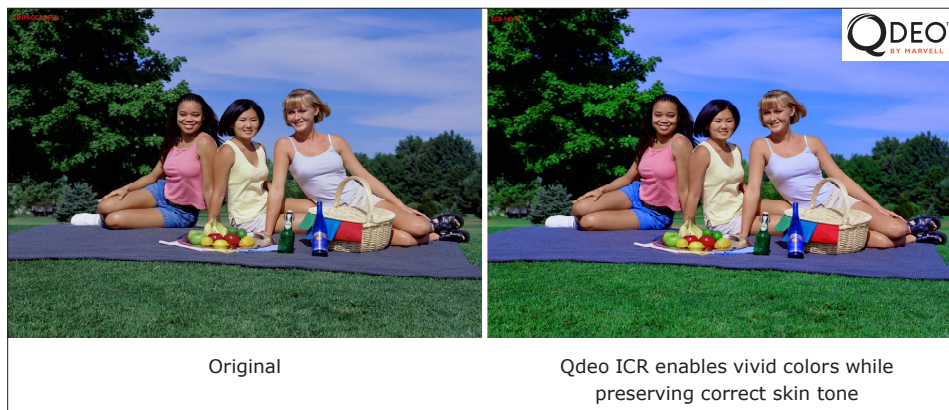


Figure 8: Qdeo Intelligent Color Remapping (ICR)

Natural Depth Expansion brings out fine details in textured regions like walls and grass and sharpens boundaries of objects like windows and grills, without introducing side-effects like halos and ringing. This helps create a sense of depth (three-dimensionality) in the displayed image. The left image in Figure 9 shows the typical softness that arises when an SD image is upscaled to Full-HD (1080p). The right image shows how the details are enhanced and a sense of depth (dimensionality) is created when Qdeo NDE is applied.

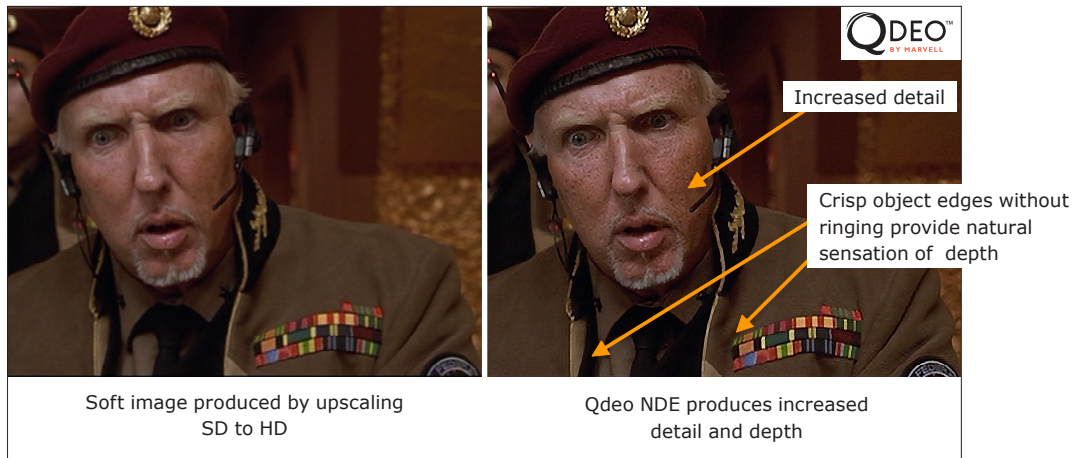


Figure 9: Qdeo Natural Depth Expansion (NDE)

Bit Resolution Expansion dynamically expands 8-bit video to use the full dynamic range offered by 10 and 12 bit displays, eliminating contours while preserving detail. This process which we refer to as **Qdeo True Color Processing (QTC)** produces a perceived higher dynamic range. Figures 10 and 11 show the results before and after application of QTC.

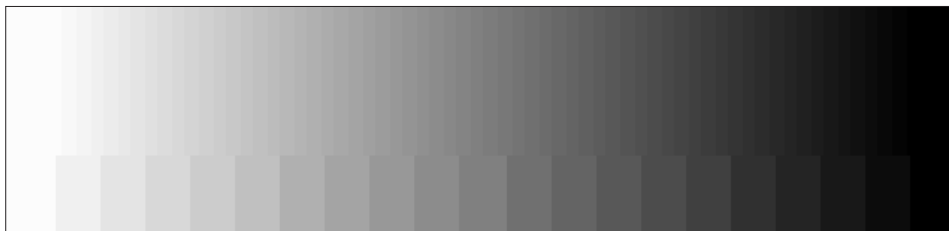


Figure 10: Gray scale ramp image BEFORE Qdeo True Color processing. The top portion of the image shows a smooth ramp that steps from black to white with steps of one lsb, and produces a perception of banding. The bottom portion of the image shows steps of 16 that represent real edges.



Figure 11: Gray scale ramp image AFTER Qdeo True Color processing. The banding in the top portion of the image has been removed while preserving the sharpness of the steps in the bottom portion of the image.

▶ APPLICATIONS OF QDEO

Qdeo video processing is currently offered in a family of video format converters from Marvell – the 88DE2710 [4] and the 88DE2750 [5]. It has already been implemented in platforms with image sizes that range from QCIF to 4K x 2K – this corresponds to a pixel count ranging from 5000 to 10M. This vast range highlights the unique adaptivity of the technology.

Qdeo video processing can be used in a wide variety of applications and platforms, including Blu-ray players and recorders, DVD players and recorders, AV Receivers, Digital TVs, Digital Projectors, Set-Top-Boxes, Digital Media Adapters/Networked media clients, Digital Photo Frames, SmartBooks, Security & surveillance, Digital signage., etc as illustrated in Figure 12.

Qdeo video processing delivers “The World as YOU See It”.



Figure 12: Examples of platforms that can benefit from Qdeo video processing

For more information on Qdeo video processing and its applications, please visit www.ClearlyQdeo.com.

▶ REFERENCES:

1. www.ClearlyQdeo.com
2. “Qdeo HD Video Evaluation” Blu-ray Disc Launched August, 2009.
3. Sujith Srinivasan et al, “Adaptive Contrast Enhancement for Digital Video”, SID International Symposium, 2007. Winner of Distinguished Paper Award.
4. Nikhil Balram et al, “Adaptive Digital Video-Format-Converter IC”, SID International Symposium 2007.
5. Nikhil Balram et al, “Adaptive Digital Video Format Converter IC Featuring Qdeo True Color and Natural Depth Expansion”, SID International Symposium 2009.

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