

It's the Quality of the Pixels that Matters™

▪ Ipera's Pixel Magic® Intelligent Video Enhancement Solutions

Video and Video Quality

Video is the fastest growing format of information in the enterprise, security, and consumer markets. User's demand, increase in processing capability and storage capacity, video compression breakthrough, and availability of content (including consumer generated content) all contributed to this trend. Video quality is a determining factor that continues to drive or hinder this growth. Users of video applications always demand better quality video, or at least, acceptable quality video, which in most situations is difficult to obtain.

One possible solution is to keep on increasing the resolution, meaning increasing the number of dots in a frame of video. However, it means all the infrastructure for existing video applications and systems will have to change. Costs will increase dramatically and delay in deployment is inevitable. Also, what about the already existing content? For the same reason, when a new standard with higher resolution comes around, the old equipments may soon become obsolete and the investment in them will be wasted. Furthermore, network bandwidth, especially that of mobile networks, is expensive and congested with traffic. More resolution means more data, and that can only worsen the situation.

Anticipating all these issues, Ipera takes a different approach: we focus on improving the pixel quality while keeping the native resolution in the content. If an application demands higher resolution, Ipera has a high quality scaler that can produce the resolution required without generating visual artifacts. The benefits associated with our new approach include:

- No delay in time-to-market.
- Video quality dramatically improved, network bandwidth actually reduced (up to 50%).
- Flexible software-based solution: upgradable, expandable, and low maintenance cost.
- Highly efficient solution that doesn't require additional hardware: no material costs, and no inventory to manage.

The Status Quo

In 2007, 22.4 billion views were logged for User-Generated Content (UGC), up 70 percent from 2006. Most of these videos were generated on cell phones or low-quality recording equipment, making the viewing experience much less than desirable. The growth of video traffic already contributed to network equipment demand, and will continue to drive the growth of technology industry for in the foreseeable future.

These users want clear, sharp images with vivid colors. The improvement of video quality will encourage them to use more video. In reality, artifacts such as distortions, noises, faded colors, blurred motion and poor lighting are all distractions that minimize the user experience.

Consider the typical flow for a conventional video processing pipeline depicted in Figure 1.

Distortions can be introduced throughout the entire procedure. Specifically:

- ◆ Discontinuities between pixels occur in the sensors when natural scenes are captured and digitized.
- ◆ Noises are generated during video capture, both spatially and temporally. In particular, temporal noise is more discernible and annoying. This is especially severe for CMOS sensors in low light.
- ◆ Blocky and mosquito effects are produced due to quantization loss in DC and some strong high-frequency components in DCT domain during video encoding. Blocky artifacts form horizontal and vertical pseudo-boundaries are very obvious in playback, especially in case of low bit-rate encoding due to higher quantization factors.
- ◆ During video encoding, deep quantization on high-frequency components in DCT domain also make video to lose details. Edges are also blurred for the same reason.
- ◆ Because only a limited gamut of colors can be received by video capturing system, colors become dim and diverge from those in real world, which causes contrast to decrease as well.
- ◆ LCD display typically has motion blur and color fading issues.

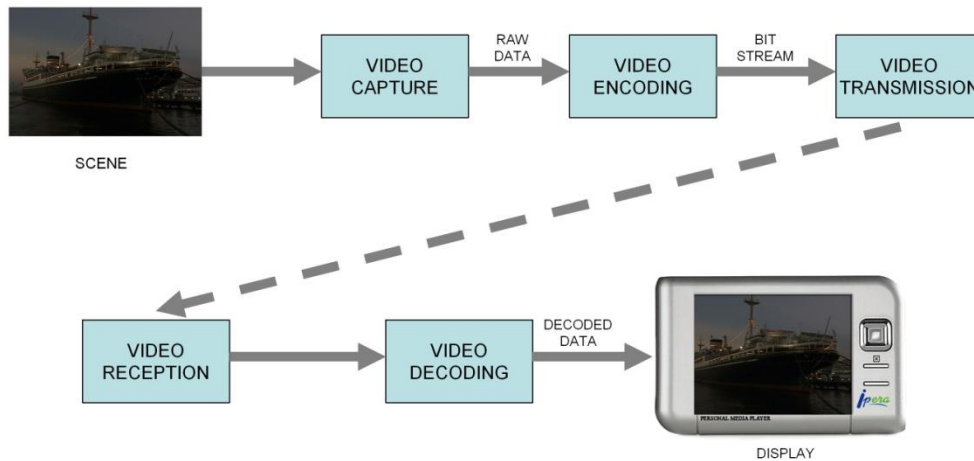


Figure 1. Conventional Video Processing Flow

Hardware and software algorithms exist in video systems and software applications that can eliminate the above distortions to a degree. However, several drawbacks are observed: First, they are not cost-effective. For instance, algorithms used for DTV's are implemented in video enhancement chips containing many millions of gates or an array of DSP's, making them too expensive and too inflexible for many applications. It is also true that it takes a few second for some software applications to enhance one photo on the PC (i.e. Adobe Photoshop) without guaranty of result. Second, the products exist today typically use static algorithms, making them scene, format, and application dependent, and in some situation, require many interventions from an experienced operator. *While in real life, same device has to play both high quality broadcast content and very low quality UGC, in many different formats from MPEG-2 to H.264, 30 frames per second. The traditional way of doing video enhancement will not work.*

Pixel Magic[®] Intelligent Video Enhancement Technology

Ipera Technology understands the above technical issues and has been purely focused on finding solutions to them. Base on many years of video experience and after more than three

years of intensive research, Ipera has developed its end-to-end **Pixel Magic**[®] video technology that solves many of the issues. **Pixel Magic**[®] video technology bridges the gap between poor-quality video that is delivered today and what the users expect. It is video codec format independent and OS independent, scalable, and with built-in intelligence, thus making it suitable for a variety of applications from enterprise, security, to consumer.

Pixel Magic[®] video technology can be integrated into numerous locations in the video encoding, transmission and decoding path as shown in Figure 2. Video can be enhanced right at where it is captured and before it is encoded to eliminate numerous imperfections created by the video capture device or after it is encoded but before transmission to enhance the video and reduce the bit-rate required for transmission. **Pixel Magic**[®] video technology is also designed to be integrated in the portable devices or streaming terminals, to enhance the video after it is received and decoded but before it is displayed on the screen. It can also be utilized at post-production studios during transcoding (including bit-rate and resolution, frame rate adjustment).

In consideration of the aforementioned distortions that degrade video quality, **Pixel Magic**[®] video technology has been carefully designed so that:

- ◆ Codec-related deficits such as blocky, ringing and mosquito effects are eliminated
- ◆ Both spatial and temporal noise is suppressed
- ◆ Brightness is adjusted towards a suitable level
- ◆ Details and edges are enhanced so that the video looks sharper
- ◆ Contrast and dynamic range are improved; black level is emphasized
- ◆ Colors are balanced/corrected and naturalized with pleasing saturation
- ◆ Motion blur for LCD display is reduced
- ◆ Video is scaled to the desired resolution for viewing without generating undesirable artifacts while keeping the sharpness

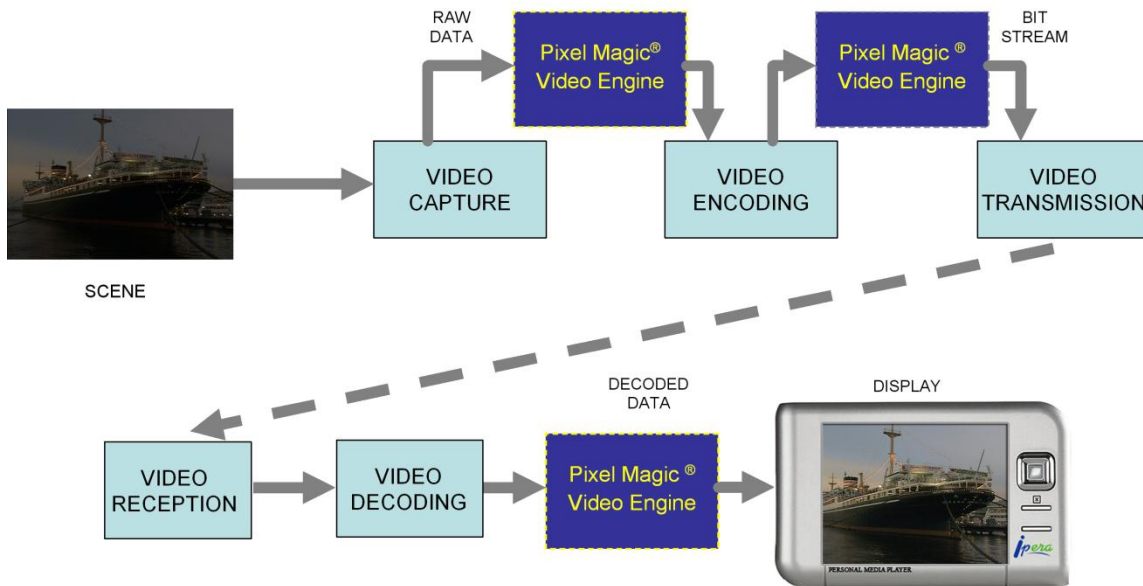


Figure 2. Video Processing Flow with the Pixel Magic[®] Video Engine

Actually the bigger challenge is not how to make each individual feature to work. Instead, it is on how to make them work harmoniously and intelligently together under various setups and scenes. Equally challenging is how to carefully craft the algorithms so that they run extremely efficiently and not to drain the battery on the portable devices; on the servers, to use less megahertz so it can process more channels simultaneously. Built-in intelligence and efficiency are two of the core strengths of Pixel Magic.

Ipera measures well on the above criteria. Its current generation of technology can enhance video content intelligently, effectively, and efficiently. On the low-end situation, it can dramatically improve video quality on 30 FPS QVGA video (typical for portable devices and handsets) using only about 100 MHz of ARM926 processing power. On the high-end PC and DSPs, high-definition and multiple channel enhancements have been achieved.

Pixel Magic[®] video technology is frame-buffer in, frame-buffer out. It's very easy to integrate into an application. We are also planning to come up with FPGA solutions and SoC cores in the future for our hardware customers.

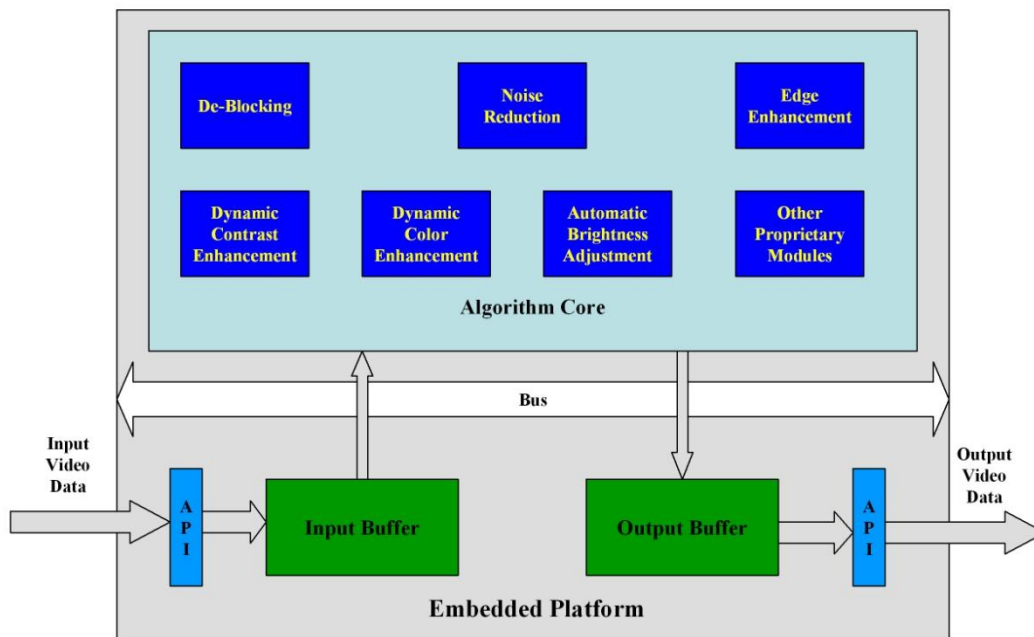


Figure 3. Architecture of **Pixel Magic**[®] video technology

Input Buffer

The Input buffer uses special memory allocation techniques to re-arrange video data into a structure that can be quickly loaded by algorithm modules, so the time for data movement is significantly reduced. It then sends video data to an algorithm core via the bus. The input buffer also provides an API (Application Program Interface) that is capable of receiving raw video data in several commonly used formats.

Algorithm Core

Video data is analyzed, processed and enhanced here. The data then goes through some or all of the video enhancement modules, depending on the results of the analysis process, the various aspects in video quality are improved. In particular, all modules work together

seamlessly and dynamically. However, they maintain a level of independence so they are upgradeable and expandable.

- ◆ The de-blocking module removes blocky effects on a block basis without requiring any bit stream information from the decoder. It also does a superb job on preserving the details. It differs from either a conventional post-filter approach (as in MPEG2/4) or an in-loop filtering scheme (as in H.264). Our solution is much more versatile and flexible.
- ◆ The noise reduction module performs 3-D filtering that suppresses spatial and temporal noise simultaneously while retaining the details. In addition, neither pseudo-outline nor tail effects are introduced.
- ◆ The edge and detail enhancement module identifies edges on different scales and classifies them into different ranks. By determining the locations and importance of edges, the power by which a particular edge shall be strengthened is leveraged. Also, texture richness is examined in some specified region, avoiding over-enhancement.
- ◆ The dynamic contrast enhancement module enables viewers to perceive details in each video frame/field by tuning contrast automatically based on specified features of the video frame/field. It also prevents enhanced adjacent video frames/fields from flickering or twittering.
- ◆ The dynamic color enhancement module enhances the colors of video frames/fields in accordance with the HVS (Human Visual System) theory. Therefore, colors become more natural, lively, and saturated.
- ◆ The automatic brightness adjustment changes the overall brightness of every video frame/field by analyzing its lighting condition, and then making use of the HVS theory adaptively, so a suitable brightness is achieved that is comfortable to viewers' eyes. This also works with our auto exposure module in case auto exposure control is possible.
- ◆ Several other proprietary modules are also contained in the algorithm core. They are capable of making video look better by diverse means.

Output Buffer

The output buffer obtains enhanced video data via the bus, and transforms it into a proper format that can be used for a specified display device. Depending upon the platform, hardware drivers can be inserted in order to accomplish some functions even more efficiently. The output buffer also provides an API that can output video data in several commonly used formats specified by the customers.

Pixel Magic[®] for Enterprise Video Applications

Pixel Magic[®] video technology is ideal to be deployed in several enterprise video applications to further improvement of end user experience. Depends on the application, either one or both of video pre-encoding or post-decoding enhancement engine can be deployed. Multiple channel solution is also possible on centralized network communication systems.

Video Conversion/Transcoding Solutions

Ipera's Technology can also be deployed on professional video conversion systems. Video transcoding is a process where video is converted from one compression format to another with bit-rate, resolution and frame-rate customized. Since all effective video codec are lossy, transcoding is typically a process where video quality is reduced. With Ipera's video enhancement technology, this is no longer the case most time, video can be dramatically

cleaned up such that the noises and artifacts in the input bitstreams are completely removed or effectively reduced. On the other hand, the inherent quality of the video, including contrast, dynamic range, color saturation and details are nicely enhanced. Usually in a bitstream, substantial amount of bits are wasted to encode the noises and distortions. When they are cleaned up, the remaining video signal can be quantized more gently so better details can be preserved. Looking at it from a different angle -- you can get better quality bitstreams at substantially lower bitrates. **Pixel Magic**[®] video technology goes way beyond the traditional method of pre-processing. Its various enhancement modules work together to bring out the best in the video content while lowering the bitrates. As we know, bandwidths are expensive for streaming providers, and saving on bandwidth is just as important to them as improvement on the quality.

Pixel Magic helps cover the limitations of the codec. When taking into consideration that most of the video content are not properly compressed to start with, **Pixel Magic**[®] video technology is very helpful in making lots of content available today a lot better.

IP Video Phone

On IP video phone system, a full-duplex communication channel is established. Both terminals encode and decode, transmit and receive video bitstreams. The video enhancement functions are split between transmit and receive end. On the transmit end, exposure is adjusted, video signal is cleaned up, 3D noises removed, color corrected and balanced, saturation enhanced before video signal is compressed by a codec and then transmitted. As a result, the video bitstream transmitted is at lower bitrate yet higher quality. On the receive end, video bitstream is decoded, then going through comprehensive further enhancements on contrast/dynamic range, color, and details/edges. Compression related distortions are also removed to produce best visual quality for the receiver. The same process is carried out for the other user, therefore improves the visual quality of two-way video communication.

Other benefits of Pixel Magic in IP Video Phone application includes:

- Very efficient so that extra computation load and memory cost are minimal.
- The enhancement/cleanup process can actually also reduce the computational load on the downstream software video encoders.

Pixel Magic[®] for Consumer Video Applications

Pixel Magic at its embedded forms, the Pixel Magic CE cores, fits into many consumer video applications such as video on cellphone (mobile TV, streaming, and playback), webcams, and settops.

Video on Cellphones

Pixel Magic CE can enable a cellphone to play back and capture video at higher quality. With consumer use their cellphones more and more for video, quality is becoming a major technological hurdle. Pixel Magic solves it by intelligently and efficiently improving your playback visual result, even on a very small screen. It removes the compression artifacts which is typically more severe for lower bitrate video used for cellphone applications. Color, detail,

contrast all can be dramatically improved. Because of the efficiency of the algorithm, it can work in tandem with a codec (typically H.264 or MPEG-4) to play back video smoothly on smartphones.

Webcams and PCs

Pixel Magic SE, a Pixel Magic implementation on X86 PCs, can help improve your video webcam quality. Today's webcam utilizes low cost CMOS sensors, and the video quality is typically not very good, especially in low light. However, the irony is that most people use their webcam in low lighted rooms, sometimes even only with the light emitted by the LCD screen. The noises could be very heavy. Most time, the noises come with big strides and exist in both the brightness (luminance) and colors (chrominance) components of the video signal, this makes noise cleanup more complicated. Pixel Magic can effectively clean up noises without creating any motion artifacts. It can also intelligently improve/balance colors, improve contrast and details on your webcam video. This makes webcam capture and conferencing a totally different experience.

Conclusion

Pixel Magic[®] video technology surpasses current video enhancement solutions by emphasizing the following differentiating factors.

- ♦ It performs video enhancement more effectively and efficiently. Every algorithm module has been carefully designed and deeply optimized so that the maximum computational efficiency has been achieved. Novel design and optimization enables the system to be operated in a real-time fashion and uses an extremely low percentage of resources available in the systems without compromising performance or quality. The solution is also fully scalable, making it suitable for digital video solutions from handhelds to servers, from sub QCIF to HD.
- ♦ It applies highly innovative and proprietary video processing algorithms developed by Ipera Technology. Its built-in intelligence makes it do the right thing for different content under different setup and scenario. The whole system is codec and OS independent, highly modular, making it easy to integrate into almost any video application.

In addition to delivering exceptionally realistic per-pixel video quality at extremely low power consumption for virtually any video codec and any video application, **Pixel Magic**[®] video technology can also be easily adapted to support future formats and other processor platforms. Network equipment manufacturers, streaming video providers, mobile OEMs and IC vendors who adopt Pixel Magic technology will find they can improve their value proposition and services to their customers now and in the future.