Darbee Visual Presence™ - Technology for Life-Like Images

Introduction

Computational image enhancement solutions are revolutionizing the way we enjoy digital content. Today improvements in processors extend digital image quality far beyond the limitations of fidelity. Features like millions of pixels and billions of colors will no longer determine the ultimate quality and realism of the image. High performance computation is now being used with image processing in new and innovative ways to enhance the quality of our digital imaging and more importantly, the experience that we have. This is analogous to the advances made in audio processing, beginning with Dolby.

Image Enhancement Solutions: Approaches

All digital image processors now incorporate image improvement processing. These processors do things like improve contrast, improve color depth, sharpen images, and filter noise. Computational image enhancement solutions now enable a level of image quality that can surpass what the most perfect camera and display can achieve. It is now possible to use computation to process an image, respectful of the way the brain will process it. By deriving algorithms inspired by the neuro-biologic models of human vision, monoscopic images can now take on new and profound properties of depth and realism. Now we can embed real depth cues in digital images, causing enhanced perception of object shape and ultra clarity. Such approaches move beyond the limitations of fidelity by leveraging principles of how the brain interprets images.

Image Enhancement Solutions: Limitations

Existing solutions are limited by fidelity or generality. The number of pixels and colors does not determine if an image looks realistic. Common global image enhancements often cause artifacts or enhance noise or unwanted parts of the image. DarbeeVision takes into consideration that human vision perception is based upon stereo vision. Without consideration and respect of this important fact, any enhancement of monoscopic detail or depth cues will be less powerful. In the marketplace, robust chip sets that perform general image enhancements are already part of all image media display systems. Now, all 2D TVs can be upgraded to Ultra HD realism without changing to more expensive display panels.

The DarbeeVision Advancement: Enhancing images respectful of our brain

DarbeeVision technology is a fundamental breakthrough for image realism. By putting into an image more of what the brain is expecting to take out, Darbee Visual Presence enhanced images help the viewer see them better. More a discovery than an invention, the Darbee approach solves two very tough challenges for monoscopic digital images:

- Problem – What is the right way to enhance monoscopic detail and depth cues?
- Answer – Use parallax disparity as the basis for luminance modulation.

- Problem – How do you avoid artifacts?
- Answer – Selectively apply modulation based upon a fast and accurate saliency mask.

Darbee Visual Presence™: Technology

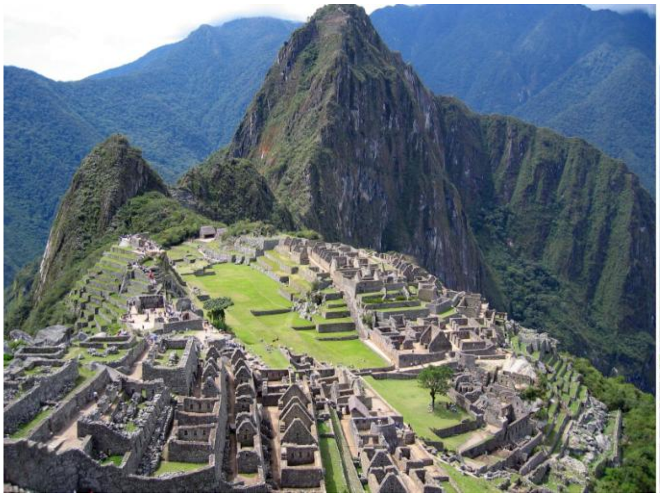
At the heart of Darbee Visual Presence there is a discovery. Paul Darbee found that you can actually embed stereo depth information into monoscopic images and achieve gratifying results. A disciplined eight years of exploration into the neuro-biologic basis for human vision has yielded a patented and powerful human-vision-based model for digital image enhancement. It has also yielded a sublime solution for making 2D images look full of depth and realism.

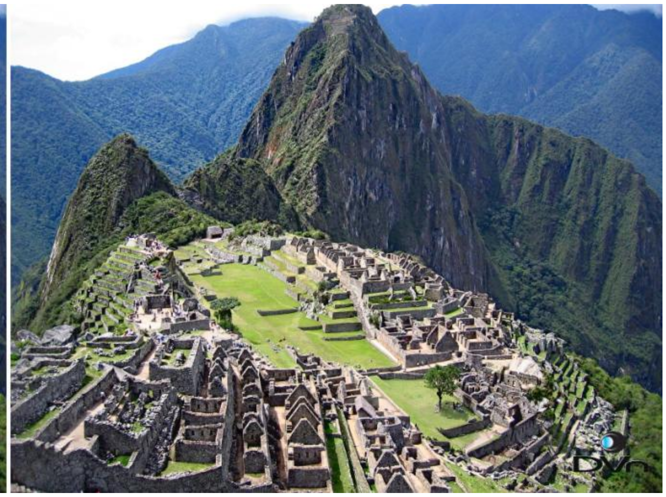
Defying conventional wisdom, Darbee technology creates a seemingly impossible image transformation. The processing happens in real time, with performance surpassing HD 1080p60. Darbee processing occurs at lightning speed and precision because both the core enhancement method and the selective application parameters have been optimized from the beginning for computational efficiency.

The image processing is done intra-frame so that no large buffer memory or time delays are required. Processing is resolution independent, scaling linearly with the number of pixels in a frame. The algorithms do disparity synthesis, then apply a patented defocus-and-subtract of the resulting images. The algorithm next applies the enhancement only to the areas of interest, via the Perceptor™, a proprietary saliency map. The processing is local, modifying the image luminance on a per-pixel basis.

The resulting improvements go far beyond what fidelity improvements alone can do for image realism. Because the results are embedded in the pixels of an image, the process can be applied any time during the life of the image. The Darbee process can be applied in digital TVs, DVD players, cable or satellite boxes, cameras, video games, mobile devices, PCs, printers, video, or movie post production—indeed, for any digital image at any time.

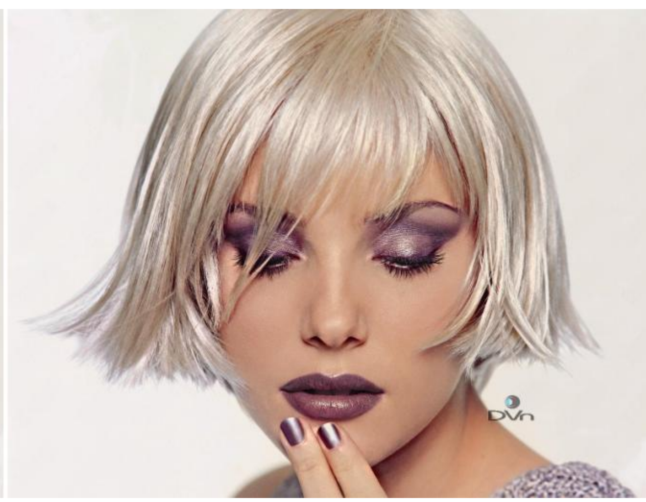
Darbee Visual Presence™: Image output example





Before DarbeeVision

After DarbeeVision



Darbee Visual Presence™: Technology Details

In the early 1970s, Paul Darbee constructed an analog video synthesizer that allowed him to perform a large number of experiments using real and synthetic moving images in real time. Working with two video cameras arranged like a pair of eyes, he searched for a way to combine the left and right stereo images from the cameras into a single two-dimensional TV picture that would not look like the double image you see when viewing today’s 3D video without the glasses. Somewhat to his surprise, he found that defocusing one of the images using the TV camera’s lens, and then using the video synthesizer to invert the defocused image and add it to the other, sharp image, the resulting

2D picture took on remarkable properties. Rather than looking like a double image, the objects in the picture had a strong sense of separation in depth, seemed more rounded, and the details were easier to see.

Darbee was using the same *defocus-and-subtract* method that photographers discovered in the 1930s when they invented the *unsharp mask*. In that well-known case, an image is defocused and subtracted from *itself*. The blurred image contains low spatial frequencies that get partially removed from the final image, which is equivalent to emphasizing the remaining *high* spatial frequencies that contain the image details. The resulting image appears sharper, but any grain or noise that may be present in the image will also be emphasized, and objects can appear to have their edges unnaturally outlined.

Despite the ubiquity of the unsharp mask in modern image processing software, defocusing one image of a stereo pair and subtracting it from the other image is quite unlike an unsharp mask. In those parts of the two images that are *different* due to the *parallax disparity* that arises from the displaced vantage points of the left and right cameras, the alterations to the final image are interpreted by the brain as genuine *depth cues*. Where the viewpoints are converged and the disparity is low, the process does revert to an unsharp mask and emphasizes image details, but in natural scenes containing 3D objects, there is always some disparity, so defocusing-and-subtracting embeds depth cues.

Graphic artists discovered a few years ago that adding *highlights* and a *drop shadow* to text makes the text appear to float in front of the background, as shown in the example below.

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VISUAL PRESENCE™

The effect is quite strong, and now we see it everywhere—in print, on TV, on billboards, and even on the sides of vans. In a sense, stereo defocus-and-subtract achieves a similar result. The simplest interpretation our brains can make of the alterations to the picture is that the modified objects are indeed three-dimensional.

Darbee was quite impressed with the strength of the effect, but at the time there did not appear to be any way to use it in mainstream technology, for two compelling reasons. First, it required a source of 3D content, and even today with the current enthusiasm for 3D movies and television, the overwhelming majority of new images, and virtually all old images, are monoscopic 2D. Second, depending on the composition of the 3D scene, defocus-and-subtract can create odd blobs and ‘wings’ that appear as unnatural artifacts in the image. Accordingly, Darbee did not commercialize or publish his findings, but he did embark on a study of neuroscience in a search for an explanation of the effect. Indeed, brains throughout the animal kingdom do embody a form of defocus-and-subtract, known in neuroscience as *lateral inhibition*. In the human visual system, lateral inhibition is ubiquitous, from the familiar *center-surround* processing in the retina up to the ocular dominance columns in the visual cortex, and in the inhibitory basket cells of the cortex.

After waiting three decades for computer science and digital imaging to advance sufficiently, Darbee recreated many of his experiments with the analog synthesizer, but this time in digital form. Desiring to begin with a single monoscopic image, and knowing that the other image of the stereo pair was going to be degraded by defocusing, he tried a number of mathematical techniques for synthesizing the second image. He did find a mathematically inexpensive way to create the other image, and despite not being suitable for viewing as a stereo pair, the other image was quite acceptable for defocusing-and-subtracting, yielding most of the 'pop' that a natural image would give.

With two images, the question arises as to whether to defocus the right image and subtract it from the left one, or to defocus the left image and subtract it from the right one. In practice, the choice didn't seem to matter much, the result being subjectively quite satisfactory either way, but the lack of symmetry led Darbee to try using his technique to synthesize *two* new images, both a left and a right one, starting from a monoscopic *middle* image. Defocusing both the left and right images and subtracting them from the original middle image gave an even stronger sense of depth and separation. Encouraged, Darbee filed for a patent on the defocus-and-subtract method, while opting to maintain the mathematical procedure for synthesizing the extra images as a trade secret. That patent, *Method and apparatus for embedding three dimensional information into two-dimensional images*, issued on May 9, 2006 as US patent number 7,043,074. Another patent has also issued.

Now able to start with any monoscopic still image or series of frames from a movie or video, the problem of getting rid of the image artifacts still remained. From his study of neuroscience, Darbee knew that the process of seeing depends to a large extent on determining what parts of the visual field to attend to and what parts to ignore, or in other words, on *attention-casting*. Within the scientific discipline of computational imaging, various methods of creating a *saliency map* have been developed for this purpose, but most of them are mathematically cumbersome with mixed effectiveness. Nevertheless, Darbee was inspired by findings within neuroscience to develop a new kind of saliency map, which he called a *Perceptor™*, that he was able to use in order to conditionally apply the defocus-and-subtract technique only to those parts of the image with visual significance. As with the method for mathematically synthesizing additional stereo views from a single monoscopic image, Darbee elected to maintain the method for generating the Perceptor as a proprietary trade secret.

The early Perceptor was able to remove most of the image artifacts, but some stubborn ones still remained. Darbee developed a number of partially-automated techniques for dealing with the remaining artifacts, and was able to develop a manually-supervised software program to process images using a render farm. That software successfully processed several motion picture DVDs, a theatrically-released movie, some TV commercials, images for billboards, and some ultra-high-resolution art prints. Despite those proofs-of-concept, Darbee realized that to go mainstream he had to find a way to fully automate the algorithm and get it to run in real time.

Years of further development have now succeeded in fulfilling the final requirements for a technology ready to be applied in consumer electronics around the world. An intellectual-property (IP) block is ready for licensed use within the real time chips currently used in digital TVs, DVD and Blu-ray players, digital cameras, video games, printers, mobile devices, and other imaging products. For those billions of legacy TVs that will never have a built-in chip, an aftermarket accessory box based on a proprietary Darbee chip is under development.

Applications

The largest application segment for DarbeeVision is digital display devices. Consumer electronics manufacturers put display panels into their products and rely upon consistent quality among their OEM panel makers. Differentiation by the manufacturer comes in waves and is typically driven by advancements in fidelity features. Size, resolution, color gamut, refresh rates, brightness, blackness, up scaling, and de-noising are examples of driving factors. These features for digital image display are virtually the same from one manufacturer to another. Within each class, the main differentiation is the cosmetic appearance of the panel housing. With Darbee Visual Presence, the differentiation will be apparent in the image.

Patent Summary

DarbeeVision was awarded a patent for the process in 2006 and 2011, has others pending and holds numerous additional associated IP assets. Key areas of innovation include embedding disparity depth cues into 2D images, a computationally inexpensive parallax disparity generator, and a very fast, very accurate saliency mask.

Darbee Products

DarbeeVision Technology is a proven solution that has been tested for digital TVs over the past year. The technology is fully mature and has gone through over 8 years of development with a highly accomplished team, which has a combined domain expertise of over 50 years.

Darbee Visual Presence Software is optimized code with unified APIs that can be implemented into any generic image processor platform.

Darbee Visual Presence Hardware is a logic core that interfaces perfectly with an LCD controller or a media co-processor. Visual Presence Hardware is a technology-independent hardware module that can be integrated in the pixel processing pathway of consumer electronic devices. It has a small form factor with no impact on existing pin footprints. An FPGA prototype of this logic core is available for customers to conduct side-by-side comparison of video quality performance.

Conclusion

Driven by the need for image differentiation, demand for real time image enhancement is growing. Current image enhancement solutions do not provide significant differentiation and the most advanced technologies are not optimized for real time or practical application. DarbeeVision has developed a proprietary technology, Darbee Visual Presence, which brings a revolutionary and never-before-seen level of depth and realism to 2D images. By integrating Darbee Visual Presence into existing digital image media devices, pictures can be made better than what even the most perfect camera and display can achieve—much better in fact, by using computation to process an image in the same way the brain does.