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# Analysis and Evaluation of Software Tools for Creating HDR Images From LDR With Multiple Exposures

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**Abstract**

The human visual system has the capacity of instantaneously receiving a large amount of visual information about an abundance of details and numerous colors in a different dynamic range of light. To reproduce this is challenging since even the latest technology has limited abilities regarding the representation of the actual lighting. The HDR technology reproduces lightning rather faithfully. As a result, different techniques and software tools for creating HDR images are currently being developed. So far, combining LDR images of the same scene, taken with different exposition times, to produce an HDR image, has seemed to be the most reliable and the most common method in use. The area is in the early stages of development, so several software development companies are working on tools for the purpose of getting better and better results. Since neither a standardized method nor a possible candidate for a superior or even a preferable tool has emerged up to now, assessing the quality of HDR images created with each of the available and marketed tools appears to be an inevitability. The evaluation in this case is, nevertheless, a delicate matter, since the end user is the human eye, i.e., the very subjective human perception. To overcome this difficulty, both psychophysical and psychometrical experiments are extensively used. The study is aimed at analyzing the possibilities and the end results of the LDR-to-HDR procedure, using each of the leading software tools for creating HDR images. The goal is to contribute to the creation of standard methods and tools for creating images with high dynamic range.

*Keywords:* high dynamic range imaging, digital photography, HDR techniques, computer graphics, HDR image formats.

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## Introduction

High Dynamic Range Imaging (HDRI) is a set of techniques used in photography, computer graphics and image processing to capture, process, and display a greater range of luminance levels than traditional imaging methods, thereby producing images that more accurately represent the wide range of intensity levels found in real scenes, from direct sunlight to faint starlight [1].

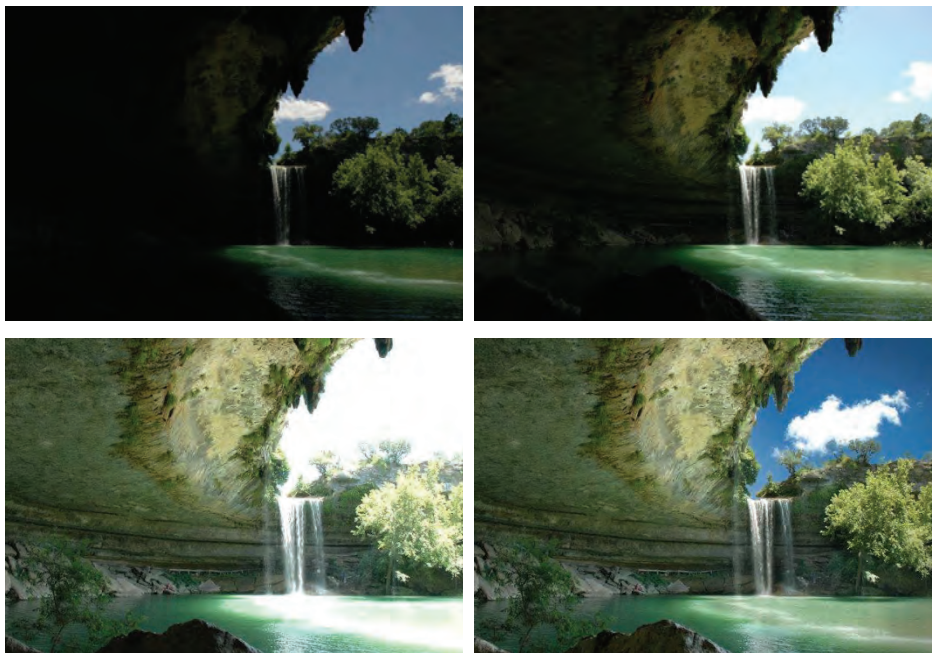
HDRI involves capturing multiple images of the same scene at different exposure levels and combining them to create a single image with enhanced dynamic range [2] [3]. This process can be achieved using various methods, such as the use of multiple cameras arranged in parallel to capture images simultaneously [4] [5], or the use of a single camera to capture images with different integration times [6]. The resulting HDR images contain pixels that represent a much greater range of colors and brightness levels, making the visual content appear more realistic and appealing [7] [8]. Advances in HDRI also include techniques for encoding and compressing HDR images and video, tone mapping for displaying HDR content on standard dynamic range displays, and inverse tone mapping for upscaling legacy content for HDR displays [9]. Additionally, HDRI can be used in image-based lighting to illuminate computer-generated objects and integrate them realistically into real-world scenes [10]. The development of the HDRI technology has led to significant improvements in image fidelity, making it a key technology in the future imaging pipeline. Various methods, such as reducing intensity laser pulses in microscopy and combining low-resolution and high-resolution images captured at different exposure levels, further enhance the dynamic range and quality of HDR images. Overall, HDRI represents a significant advancement in digital imaging, offering a more accurate and visually appealing representation of real-world scenes.

## HDR from Multiple Exposures

The primary advantage of HDR imaging is its ability to produce images with a higher dynamic range than what is achievable with a single exposure. This capability is particularly beneficial in scenes with extreme contrasts, such as landscapes with bright skies and dark shadows. By merging multiple exposures, HDR imaging ensures that details in both highlights and shadows are preserved, resulting in more visually appealing and realistic images. Figure 1 shows the difference between LDR images and a High Dynamic Range Image.

**Figure 1**

*Exposing for the sky, 2. Center exposure, 3. Exposing for the rock, 4. HDR*



By capturing multiple images at different exposure levels, it is possible to ensure that each part of the scene is correctly exposed in at least one of the images. The concept of using multiple exposures to address a wide range of luminance values dates back to the 1850s, when Gustave Le Gray pioneered this technique to depict seascapes with both the sky and the sea accurately rendered. In contemporary practice, software tools are employed to amalgamate the information from these various exposures into a single image that is uniformly well-exposed.

**Figure 2**

*Gustave Le Gray - Brig upon the Water, the first HDR image*

To successfully create HDR images from multiple exposures, the following equipment is essential:

Digital camera: A DSLR or mirrorless camera with exposure bracketing capability is preferred for capturing the necessary range of exposures.

Tripod: Ensures stability and minimizes movement between shots, which is crucial for aligning multiple exposures accurately.

Remote shutter release: Reduces camera shake during exposure, ensuring sharp images.

HDR software tools: Specialized software is required to merge the multiple exposures into a single HDR image.

## The HDR Process

1. Capturing multiple exposures

The first step in creating an HDR image involves capturing multiple exposures of the same scene. Typically, three to five exposures are sufficient, with each exposure differing by one to two EV steps. The detailed process is as follows:

Set up the camera: Place the camera on a tripod to ensure stability. Enable the exposure bracketing mode on the camera, which automatically captures multiple exposures with different exposure values.

Maintain a static scene: Ensure that the scene remains static during the capture process to avoid ghosting effects. Use a remote shutter release to minimize camera shake.

Capture exposures: Take the required number of exposures, ensuring that the entire range of luminance levels in the scene is covered.

2. Combining exposures using software

Once the multiple exposures are captured, the next step is to merge them using HDR software. Several tools are available, each offering different features and levels of control. Popular options include:

Photomatix Pro: Known for its robust HDR capabilities, Photomatix Pro offers automated and manual ghost removal, noise reduction, and a variety of presets for different effects.

HDR Efex Pro: This plugin for Adobe Photoshop provides excellent ghosting control, multiple presets, and seamless integration with other Adobe tools.

Adobe Photoshop HDR Merge: Offers automated picture alignment and ghost removal, with options for 8-bit, 16-bit, and 32-bit modes.

3. Adjusting the HDR image

After merging the exposures, fine-tuning of the resulting HDR image may be necessary. Common adjustments include:

Tone mapping: Adjusting the local contrast to bring out details in both shadows and highlights. Tone mapping is crucial for achieving a natural look and preventing the image from appearing too flat or overly dramatic.

Color correction: Enhancing or correcting colors to achieve the desired look. This step ensures that the colors in the HDR image are vibrant and true to life.

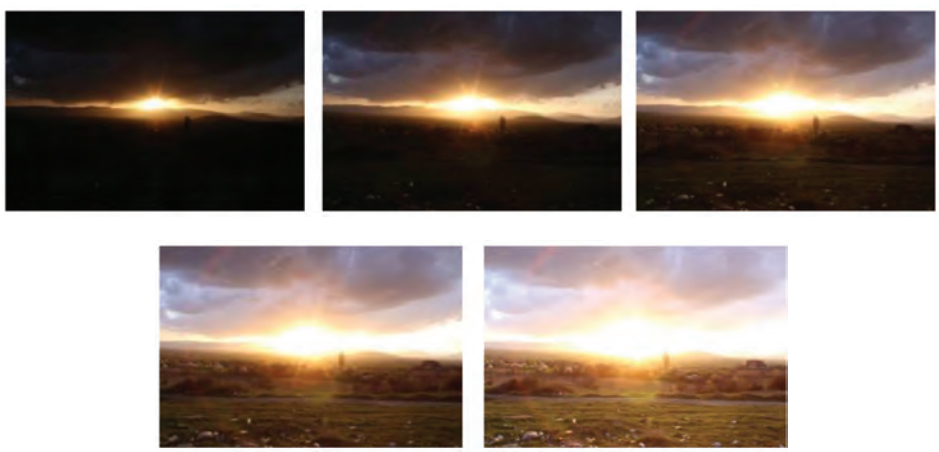
Noise reduction: Minimizing noise that may have been introduced during the merging process. Effective noise reduction techniques help maintain image quality and clarity.

## Evaluating HDR Software Tools

To evaluate the HDR software tools, the following experimental procedure was conducted. Five low dynamic range (LDR) images were captured without the use of flash, saved in TIFF format, with exposure variations of -2 EV, -1 EV, 0 EV, 1 EV, and 2 EV. Each image had a resolution of 5392x3598 pixels. Every software tool was provided with the same input images of the same scene. The final HDR results were analyzed based on three criteria: price, quality of the HDR image, and supported file formats.

**Figure 3**

*LDR images with different exposure values -2 EV, -1 EV, 0 EV, 1 EV, and 2 EV*



Results:

Adobe – Photoshop HDR Merge

| |
|---|
| Price - 30$ -per month the latest version |
| Input formats – All picture formats (Incl. JPG, TIFF, RAW) |
| Ghost removal – Automated |
| Automated picture alignment |
| 8 bit 16bit 32bit mode (16 bit gives the best results) |
| 16 Presets |
| Export formats supported (TIFF; JPG; Open EXR; Radiance (. HDR;. RGBE; .XYZE) |

**Figure 4**

*HDR image result from Adobe – Photoshop HDR Merge*

HDR Soft - Photomatix Pro

| |
|---|
| Price – 100$ |
| Input formats – All picture formats (Incl. JPG, TIFF, RAW) |
| Ghost removal – Automated&manually |
| Reduce noise |
| Reduce chromatic aberrations |
| Align&Crop source images |
| 8 bit 16bit 32bit mode (16 bit gives the best results) |
| 32 Presets (result preview) better results |
| Export formats supported (TIFF; JPG) 8 bit & 16 bit |

**Figure 5**

*HDR image result from Photomatix Pro*

HDR Efex Pro

| |
|---|
| Price – 150$ |
| Input formats – All picture formats (Incl. JPG, TIFF, RAW) |
| Ghosting control with reference image |
| 8 bit 16bit 32bit  mode (16 bit gives the best results) |
| 28 Presets (Compare with the original) |
| Export formats the same as Photoshop |
| Need host application (Photoshop)-Works as plugin |

**Figure 6**

*HDR image result from HDR Efex Pro*

## Discussion of Results

The evaluation of the HDR software tools reveals distinct differences in terms of price, quality of HDR images produced, and supported formats. Adobe Photoshop HDR Merge, HDR Soft Photomatix Pro, and HDR Efex Pro were analyzed using a consistent set of five low dynamic range (LDR) images with varying exposures (-2 EV to +2 EV).

### Price Analysis

Adobe Photoshop HDR Merge, at $30 per month, offers a cost-effective solution compared to the one-time costs of HDR Soft Photomatix Pro ($100) and HDR Efex Pro ($150). While Adobe's subscription model may be advantageous for users already integrated into the Adobe ecosystem, it could be seen as less favorable for those seeking a single purchase option.

### Quality of HDR Images

Quality assessment involved evaluation of the HDR images for clarity, ghost removal effectiveness, and overall visual appeal. Adobe Photoshop HDR Merge provides automated ghost removal and picture alignment, producing high-quality images with 16 available presets. However, Photomatix Pro, with both automated and manual ghost removal, noise reduction, and 32 presets, tends to deliver superior results, especially in scenarios requiring fine-tuned adjustments. HDR Efex Pro, despite its higher price, also delivers high-quality images with robust ghosting control and 28 presets, but it requires integration with Adobe Photoshop, which may limit its standalone usability.

### Supported Formats

All three software tools support a wide range of input formats including JPG, TIFF, and RAW. Adobe Photoshop HDR Merge and HDR Efex Pro offer extensive export formats, including TIFF, JPG, OpenEXR, and Radiance (.HDR). In contrast, Photomatix Pro supports fewer export formats, limited to TIFF and JPG. This limitation might influence users, who require versatile output options for different applications.

## Conclusion

In this study, we evaluated several HDR software tools by capturing five LDR images with varying exposures and processing them through Photomatix Pro, HDR Efex Pro, and Adobe Photoshop HDR Merge. The analysis was focused on the quality of the resulting HDR images, the cost of the software, and the supported formats.

The results showed that each software had unique strengths and weaknesses. Photomatix Pro excelled in noise reduction and offered a wide range of presets, making it a versatile choice for different HDR effects. HDR Efex Pro provided superior ghosting control and seamless integration with Adobe tools, making it a suitable option for users already working within the Adobe ecosystem. Adobe Photoshop HDR Merge was found to be highly effective in picture alignment and ghost removal, with flexible output options in 8-bit, 16-bit, and 32-bit modes.

Overall, the choice of HDR software depends on the specific needs of users, including their workflow preferences, the importance of certain features, and budget constraints. Photomatix Pro stands out for those seeking robust HDR capabilities with extensive customization options, while HDR Efex Pro is ideal for Adobe users prioritizing integration and ghosting control. Adobe Photoshop HDR Merge offers a balanced solution with strong alignment and ghost removal capabilities.

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