An Overview on Evolution, Application, Suggested Process for HDRI

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***Abstract*—**The computer graphic industry, gaming industries and some photographic related industries wanted a 'realistic' pictures from outsides (i.e.) world. But earlier stage the photographic field using low dynamic range images. From the low dynamic range we cannot get the whole real values from an image. Some values may be disordered and some artifacts occurred on an image. So we cannot get the realistic picture. To overcome these problems we have to introduce high dynamic range image. An earlier the single scene captured by single short in LDRI. So, we cannot get the real values of an image but HDRI the single short captured by three different exposure. Combine the low intensity value images into the high dynamic range image through Tone mapping techniques. Finally using the HDRI gets the 'realistic' values from natural world. This paper focus on one of the emerging technologies and how it can be developed in achieving effective solution. We introduce evolution of HDRI, process of HDRI, and framework process. This paper concludes with discussions and list of application in HDRI.

***Keywords*—**Exposure; Intensity; Dynamic; Luminance; Response Curve.

***Abbreviations*—**Complementary Metal Oxide Semiconductor (CMOS); Digital Pixel Sensor (DPS); High Dynamic Range Image (HDRI); Low Dynamic Range image (LDRI).

I. INTRODUCTION

A single picture is unable accent all the details due to the different light distribution. HDR photography overcomes that by combining several pictures with different exposure settings to produce an image that shows all areas in full detail. HDRI technique is more important in photography today. A larger exposure image represents both light and dark areas equally. High-dynamic-range imaging is a set of methods used in imaging and photography to capture a greater dynamic range between the lightest and darkest areas of an image than current standard digital imaging methods or photographic methods. HDR images can represent more accurately the range of intensity levels found in real scenes, from direct sunlight. HDR methods provide higher dynamic range from the imaging process. Non-HDR cameras take pictures at one exposure level with a limited contrast range. This results in the loss of detail in bright or dark areas of a picture, depending on whether the camera had a low or high exposure setting. HDR compensates for this loss of detail by taking multiple pictures at different exposure levels and intelligently stitching them together to produce a picture that is representative in both dark and bright areas.

Figure 1: High-Dynamic-Range (HDR) Image made out of Three Pictures

The dynamic range is a ratio between a maximum and minimum physical measure. In photography, its definition depends on what the dynamic range refers to.

- For a scene: ratio between the brightest and darkest parts of the scene.
- For a display: ratio between the maximum and minimum luminance's emitted from the screen.
- 8- Bit Images (i.e. 24 bits per pixel for a color image) are considered Low Dynamic Range.
- 16 – Bit Images (i.e. 48 bits per pixel for a color image) resulting from RAW conversion are still considered Low Dynamic Range, even though the range of values they can encode is much higher than for 8 – bit images (65536 versus 256).

- 32- Bit images (i.e. 96 bits per pixel for a color image) are considered High Dynamic Range. 32 – Bit images are coded using floating point numbers.

HDR is also commonly used to refer to display of images derived from HDR imaging in a way that exaggerates contrast for artistic effect. The two main sources of HDR images are computer renderings and merging of multiple low-dynamic-ranges (LDR). Tone mapping methods, which reduce overall contrast to facilitate display of HDR images on devices with lower dynamic range, can be applied to produce images with preserved or exaggerated local contrast for artistic effect. High-dynamic-range photographs are generally achieved by capturing multiple standard photographs, often using exposure bracketing, and then merging them into an HDR image. Digital photographs are often encoded in a camera's raw image format, because 8 bit JPEG encoding doesn't offer enough values to allow fine transitions (and introduces undesirable effects due to the lossy compression). Any camera that allows manual over- or under-exposure of a photo can be used to create HDR images. This includes film cameras, though the images may be digitized for processing with software HDR methods. Shooting HDR scenes with conventional digital cameras requires photographing a sequence of exposure-bracketed Low Dynamic Range (LDR) captures, and then using to merge them into a single HDR file. The HDR file is then "Tone mapped" back into an LDR image that can be displayed and printed. Tone mapping method reduces the overall contrast of an image in LDRI [Jonathan Cohen et al., 2001].

1.1. Comparison of HDRI with Traditional Images

Traditional images are stored the pixel values in a fixed integer format. So it cannot store all the pixel values of an image. HDR images often don't use fixed ranges per color channel other than for traditional images to represent many more colors over a much wider dynamic range. For that purpose, doesn't use integer values to represent the single color channels (e.g., 0...255 in an 8 bit per pixel interval for red, green and blue) but instead use a floating point representation [Debevec, 1998]. Common are 16-bit or 32-bit floating point numbers to represent HDR pixels.

1.2. Limitations

Real-world dynamic range is far greater than 256 intensity levels in the natural world 100 000 000:1. That the eye can accommodate in a single view 10 000:1.That a typical CRT/LCD monitor can display 100:1. Capturing and display devices support a very limited range of luminance [Lee Frost, 2000]. Limited luminance range and limit color gamut (only RGB color) displayed in low dynamic range imaging. High luminance range and Full color gamut (i.e. all colors) displayed in High dynamic range imaging.

1.3. Tone Mapping

High dynamic range images are generated using special cameras that capture multiple low dynamic range (LDR) images with different exposures times. Then these images are combined together in order to get an image with high dynamic range. Displaying devices has limited dynamic range; most display devices support 24-bit per color pixel. HDR images are reproduced into a lower dynamic range in order to be displayed in normal display devices [Reinhard et al., 2005]. Tone mapping is the process of reducing the dynamic range of the HDR image in order to be displayed on an LDR displaying device while maintaining the image integrity. Tone Mapping is the process of converting the tonal values of an image from a high range to a lower one. For instance, an HDR image with a dynamic range of 100,000:1 will be converted into an image with tonal values ranging from just 1 to 255.

1.4. Applications

- Global illumination techniques (physically-based rendering)
- Mixed reality rendering (special effects for movies and commercials)
- Human vision simulation and psychophysics
- Satellite imaging (remote sensing)
- Digital compositing for film
- Digital cinema

Today, the main users of HDR imaging devices are specialized professionals working in the film, animation and VR industries. Some applications are listed below.

Film

Tools such as HDRShop by Paul Debevec enable to convert a series of photographs into a light probe - a special image that represents the lighting environment in a room. It can then use the light probe to light virtual objects, so that the virtual objects actually appear to be lit by the light from the room. This technique is especially useful for compositing computer graphic objects into images of real scenes. Hollywood films use light maps extensively to blend CGI into a scene.

Panoramas

Another use for HDR is in panoramic images. Panoramas often have a wide dynamic range, e.g. one part of the panorama may contain the sun, and another part may be in deep shadow. Online web panoramas constructed from HDR images look much better than non-HDR equivalents.

Games

A third use for HDR is in computer games. Recent computer graphics cards support HDR texture maps. With HDR texture maps, you can render objects using light probes, in real time, yielding much more dynamic and interesting lighting effects. "High Dynamic Range Lighting Effects" are used in many new high-end games.

II. HDRI EVOLUTION

The pixel values are not correlated to luminance in the real scene, they merely indicate if one object is more or less bright than another. Recent advances in HDRI have shown how those limitations may be overcome [Battiato et al., 2003]. With HDRI, images of the real world may be accurately captured, stored process and displayed.

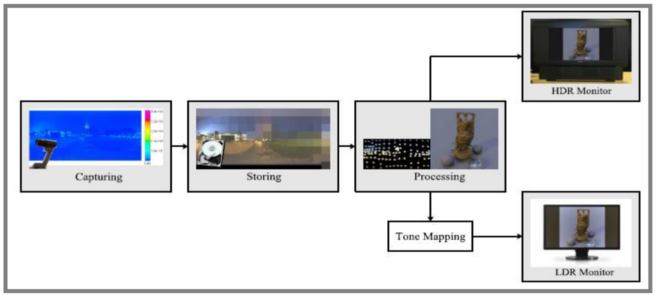


Figure 2: Pipeline Process

First the scene capture by the lens using stutter speed, aperture, dynamic range. HDR files using these extra bits are also used more efficiently than typical 8 or 16-bit images ("low dynamic range images"). The LDR file format is able to record a minimum dynamic range values. The values are stored in fixed integer values. So it could not able to store large amount of color information. The 32-bit HDR file format is able to record a greater dynamic range because it uses its bits to specify floating point numbers. The storing image is processed by some tone mapping algorithms for get a HDR image [Mann & Picard, 1995]. Finally, compress the HDR images in order to display them on LDR displays. Tone mapping is the operation that reduces the dynamic range of the input content to fit the dynamic range of the display technology.

2.1. HDRI Formation

High dynamic range image, referred as HDRI is a combination of multiple images with different exposures. The very dark and bright areas of a scene can be recorded at the same time into an image, avoiding under-exposed and over-exposed areas [Debevec, 1998]. There are three formation steps are using in HDRI.

2.1.1. HDR Image Acquisition

There are two examples of new imaging sensors which can take an HDR scene in one shot: Digital Pixel Sensors (DPS) and high dynamic range CMOS (HDRC). DPS climb more transistors to pixels. So each pixel has its own analog-to-digital converter and its own logic circuits. Since DPS are capable of 10,000 frames per second. After taking pictures with several exposures for each capture, they are combined into an HDR image at the lowest levels in each pixel signal. Another new imaging sensor is high dynamic range CMOS (HDRC), a CMOS-based sensor with per-pixel readout logic. HDRC can capture each frame with up to four differently exposes captures to create an HDR image [Ward, 1994]. Both approaches depend on how many transistors can be mounted on a chip. The cameras with such new imaging sensors are already available however; a big drawback of those highest-end sensors is their cost.

2.1.2. Multi-Exposure Techniques

A basic idea of multi-exposure techniques is that an HDR image is reconstructed from a series of LDR images with different exposures taken by the same camera from the same position. Several multi-exposure algorithms have been introduced such as. Each algorithm has a different strategy for recovering the response curve of a camera which is needed to express pixel values for each LDR image in the same intensity space.

2.1.3. 3D Renderers for HDR Images

There is a number of 3D rendering methods to produce HDR scenes in

- The classical photorealistic rendering approaches such as scan line use the lighting model of direct illumination. It can place fake objects to make the final result as HDR, for example, negative lights, shadow mapping, textures, and ramps. These approaches are the simplest and fastest methods to render HDR scenes; however, they require the users to have experience and artistic skills.
- Physically based rendering methods can produce more visually accurate results than the classical approaches, however, they still require some talent and experience for the users.
- Image-based lighting method is more intuitive and has a huge potential to make use of HDR imagery [Ward, 1994]. Image based lighting firstly records environmental lighting characteristics in an image of a sphere, then the recorded characteristics of the surroundings are taken into account with the rendered scene by using global illumination technique [Reinhard et al., 2007].

III. PROCESS OF HDRI

In HDRI process it will be divided into four parts. Such as scene selection, LDRI sequence shoot, Assembly and HDRI formation, photography skills for HDRI.

3.1. Scene Selection

The selection of scene is most important in HDRI process. It captures the scene data between dark regions to bright regions. The lighting of the image is more important.

3.2. LDRI Sequence Shoots

In the HDRI process, the next step after the scene selection is shooting the sequence of images with different exposures. The single scene is captured by different exposures via changing the shutter speed. Different shutter speed the image will be captured in different exposure. To avoid the displacement in camera while shooting the sequence of images.

3.3. Assembly and HDRI Formation

Combine the different low dynamic exposure images into a HDRI formation. Those images must be in a same scene. So get a good dynamic range and real values in HDRI.

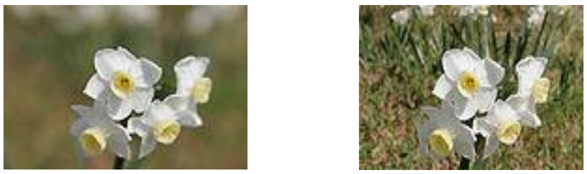
3.4. Photography Skills for HDRI

Photography skills are most important before developing HDRI process. This includes the aperture, dynamic range, F-stop, depth of field and shutter speed.

3.5. Related Terminologies

3.5.1. Aperture

Aperture is the diameter of a camera's lens opening. An aperture is a hole or an opening through which light travels. If an aperture is narrow, then highly paralleled rays are admitted, resulting in a sharp focus at the image plane. A wide aperture results in an image that is sharp around what the lens is focusing on and blurred.



(a) Small Aperture and Slow Shutter Speed

(b) Large Aperture and Fast Shutter Speed

Figure 3

Set the exposure too low in a camera, then the camera can only manage to capture the portions of the scene that are very bright. Set the exposure too high then the camera can see some of the dimmer portions of the room, but the brighter portions start to cause blooming and glare, and to wash out other portions of the image [Wicked Sago, 2013]. To overcome those problems then Extending dynamic range by combining differently exposed pictures".

3.5.2. Exposure Bracketing

Exposure bracketing is a simple technique professional photographers use to ensure they properly expose their pictures, especially in challenging lighting situations. Exposure bracketing means it takes two more pictures: one slightly under-exposed (usually by dialing in negative exposure compensation, say -1/3EV) [Steve Mann, 1993]. Second one slightly over-exposed (usually by dialing in positive exposure compensation, say +1/3EV), again according to your cameras light meter. Now, most digital cameras have auto exposure bracketing (AEB), it select that option before taking your shot, the camera will automatically take three shots:

- One which it thinks it has perfectly exposed;
- Second one slightly under-exposed;
- Third one slightly over-exposed.

The amount of under- and over-exposure usually defaults to -1/3EV and +1/3EV, but can also sometimes to specify in SETUP. Before capturing the image, an exposure value is calculated by the light meter, this value is chosen as the exposure settings. Exposure bracketing is a technique of taking several photos with varying exposures. A digital camera can change exposure in several ways. When it comes to HDR photography, it's essential that exposure is controlled by shutter speed while keeping aperture and ISO sensitivity fixed.

3.5.3. Dynamic Range

Dynamic range is the amount of detail present in a scene, a camera can capture. Dynamic range in photography describes the ratio between the maximum and minimum measurable light intensities (white and black, respectively) [Ahmet Oguz Akyuz & Erik Reinhard, 2007].

The dynamic range of a digital camera can therefore be described as the ratio of maximum light intensity measurable (at pixel saturation), to minimum light intensity measurable (above read-out noise). The most commonly used unit for measuring dynamic range in digital cameras is the f-stop, which describes total light range by powers of 2. A contrast ratio of 1024:1 could therefore also be described as having a dynamic range of 10 f-stops (since 210 = 1024). Depending on the application, each unit f-stop may also be described as a "zone" or "eV."

3.5.4. F-Stop

The unit of measuring aperture is called F-stop. There are two factors in creating exposure: The time light is allowed in and the amount of light that is allowed in to the camera. The math for exposure is exposure is equal to time multiplied by intensity [Smith, 2007].

$$E = T \times \mathrm{I}$$

A shutter opens up for a moment and closes. This is called shutter speed. Shutter speeds can vary from the very fast (e.g. 1/8000 second) to very long (e.g. 1 minute). This is more difficult to understand is how the camera determines the amount of light into the camera. This is determined by f/stop.

3.5.5. Depth of Field

Depth of field is controlled by changing the aperture setting on camera. Like our eye, a camera lens has an iris inside that can open or close to let in more or less light. It controls the size of this hole, or aperture, by changing the aperture setting, which is measured using a scale of f-stops. The larger the aperture, the shallower your depth of field will be, meaning a smaller portion of your image will be in focus.

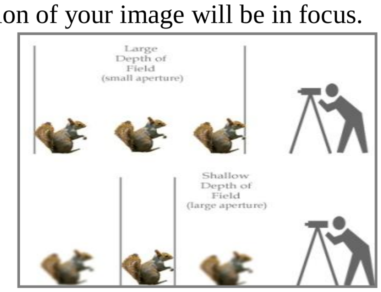


Figure 4

A small F-Stop is a large aperture opening and a large F-Stop is a small aperture opening. Because a smaller aperture limits the amount of light entering the lens, a large F-Stop also requires more light to properly expose an image.

3.5.6. Shutter Speed

The camera's shutter speed, the lens's brightness (f-number), and the scene's luminance together determine the amount of light that reaches the film or sensor (the exposure). Exposure value (EV) is a single quantity that accounts for the shutter speed and the f-number. Multiple combinations of shutter speed and f-number can give the same exposure value.

Figure 5: Shutter Speed

In the above figure shows the photograph to the right was taken with a slower shutter speed than that to the left, creating a more pronounced motion blur effect and longer streaks of light from vehicle headlights. Slower shutter speeds are often selected to suggest movement in a still photograph of a moving subject [Blain Brown, 2002].

IV. Framework Process

4.1. Histogram Equalization

Histogram equalization is performed on each image; the purpose to do so is to normalize the image. Histogram equalization is a process of automatically determining a transformation function which produces an image with a uniform histogram. The results from this technique are predictable. It is fully automatic.

4.2. Edge Detection

Edges correspond to discontinuities in the homogeneity criterion for segments. The edge detection process obtains three edges vector and sums it all together. Finally the resultant edge vector is digitized.

4.3. Zigzag

Zigzag is the standard operation in image processing. The initial idea behind zigzag is to obtain a vector for analyzing at a later stage. The zigzag pattern is applied. so that the matrix takes a new row of the vector shape. This process helps in reducing the matrix size representation when the zeros are extracted from the resultant vector in the ‘Extract Zeros’ process.

4.4. Extract Zeros

Extract zero is a simple process that is used to extract all zeros out of any vector under observation or analysis. We utilize it to remove all the zeros in the obtained resultant vector. The framework is developed on simple digital image processing concepts. All reference images are required to go through ‘Edge Detection’ process. Each image in the sequence will pass through ‘Histogram Equalization’ stage. The edges of the sequence are subtracted from the reference image to obtain the difference in the image and edge detection. The results of the difference images are summed up and passed through the ‘Zig Zag’ process to obtain 1 row vector. The zeros in the one row vector are extracted the ‘Extract Zeroes’ process. The final calculated vector is the result of the process, analysis of which reveals the camera movement while the images are being taken.

V. Experimental Result

Some of the best outdoor photography opportunities can often result in disappointing results. The pictures never seem to look the same as in real life. This is especially problematic in shooting sunsets, backlit shots, and dramatic cloud pictures. The problem is primarily due to dynamic range limitations of photography. Dynamic range is the ratio between the brightest and darkest areas of a scene. Film and digital sensors just cannot capture the full range of light seen in nature. The worst cases are shooting towards the sun at or near sunset, where the sky is very bright, but the land is dark and shaded. Usually, shooting sunsets results in silhouettes, where the sky is properly exposed, but the foreground is black and featureless. Another situation, with somewhat less dynamic range, is shooting scenery with a bright sky and clouds. Exposing properly for the sky and clouds often results in the land being too dark.

Figure 6: The sky and clouds are very bright. The low angle of the sun creates deep shadows on the hills. With the sky exposed properly, the shadowed areas would normally be black and foreground would be dark. HDR processing keeps the sky properly exposed, while bringing out the details in the shaded areas

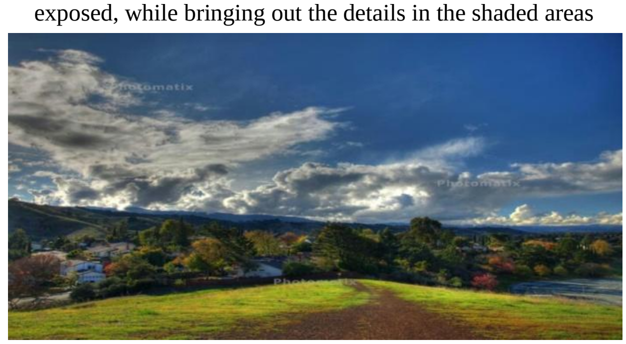


Figure 7: The sun is just to the left of the frame, brightly side-lighting the clouds. Most of the mid-ground is in shade. The foreground is brightly sunlit. HDR processing equalizes all of these

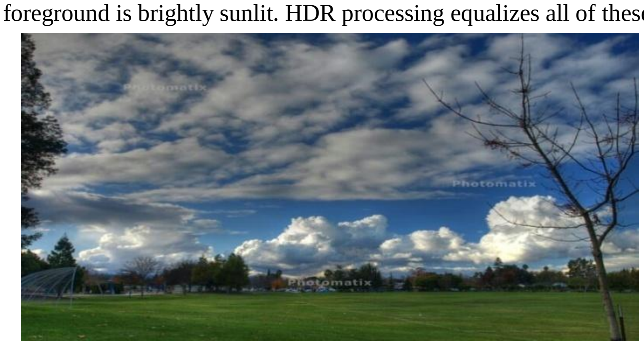


Figure 8: The sun is behind the clouds, highlighting parts of the clouds, but leaving the foreground in shadow. HDR processing keeps the foreground from getting too dark

Figure 9: This is shooting directly towards the sun, which is behind the clouds. In a normal photograph, if the clouds and sky were properly exposed, the foreground and hills would be nearly black

Figure 10: This is another mix of bright clouds, partially sunlit mid-ground, and the foreground in shadow

VI. Conclusion and Future Work

This project concludes the basic understanding of the HDRI. HDRI Process, Framework process and applications. In this paper concludes study overview of HDRI process and how it will works on digital photography. It describes the capturing, storing, processing and displaying of the High Dynamic Range Image. The camera speed, aperture, shutter speed is most important for HDRI. An HDR image stores values corresponding to the luminance of the real scene with a reasonable accuracy, which may be further improved through additional camera calibration. Although taking HDR images with cameras is time-consuming and effective. Computer graphic industries and gaming industries are needed to develop the high dynamic range images. Analyzed how it provides a cost and time effective solution.

A scene capture by a camera at that time some artifacts will be occurring on those images. Then we combined those LDR images to HDR using tone mapping concept. Those artifacts are not automatically detected and remove. It was manual calculation to apply artifacts removal and filtering techniques on an image. After that only we get a good image. In my future work when taken an image by camera, it automatically detect the artifacts and remove that all. It reduces the manual work and time saving also. Finally it produces an excellent high dynamic range image.

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