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High Dynamic Range Gigapixel Imaging as a Method for Eternalizing Graffiti & Urban Art in Fine Art & Fashion

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ABSTRACT

High Dynamic Range imaging techniques, used in combination with gigapixel imaging technology, allow creation of highly-detailed, evenly-exposed panoramic photographs of a space in 360-degrees. Typically obtaining correct exposure across a 360-degree plane of view is difficult, leading to blown-out highlights and muddled shadows in certain areas of the image. High Dynamic Range imaging techniques also allow for extremely saturated rendition of colors, and a compression of midtones resembling drawing or painting. This technique, when applied to the fields of fine art and fashion, yields visually striking results and exceptional design flexibility, as well as output resolution uncommon to both areas.

Keywords

Photography, Gigapixel Imaging, Gigapixel, High Dynamic Range Imaging, HDRi, HDR, Exposure, Graffiti, Urban Art, Street Art, Fine Art, Fashion, Design, Digital Textiles, Apparel, Bikini, Swimwear

INTRODUCTION

While excellent exposure across a gigapixel image (and moreover a 360-degree panoramic image) can be obtained simply by ‘averaging’ the exposure levels across the plane of view, it becomes increasingly necessary in spaces with multiple exposure ranges to utilize High Dynamic Range imaging as a tool to expose for interior and exterior spaces properly within the same image. This method becomes especially useful when photographing locations that have holes in the wall and/or exterior openings, such as doors and windows. Graffiti and large scale street/urban art wall ‘pieces’ are often found in decrepit locations in a somewhat serious state of disrepair. For this reason, a technique of high dynamic range gigapixel imaging technology is necessary to photograph such locations, and has since yielded aesthetically impressive results both in terms of extreme resolution as well as overtly saturated colors and detailed tonal properties.

INITIAL EXPERIMENTS IN HIGH DYNAMIC RANGE GIGAPIXEL IMAGING

Interest and Application of High Dynamic Range Gigapixel Imaging

Around February, 2009, a now famous gigapixel-resolution image taken with a Gigapan robotic panorama imaging head by photojournalist David Bergman of President Obama’s Inauguration surfaced on the Gigapan.org website. With the ability to make out even the notes on the military band’s music, the implications of utilizing such resolution for scientific imaging were immediately clear. Gigapixel imaging is a technique so robust in its applications that a moment in time could not only be frozen, but, much like a crime scene photograph taken for posterity by investigators, studied in detail.

While the scientific applications of such a technique are apparent, what was less clear (and became the sole interest and work of this author to discover), were the method’s implications on the field of Fine Art Photography. Fine Art is a disciple bound to relatively resolution-limited film negative and digital techniques. At high-end art galleries around the world, for instance, photographic prints are usually limited by the original size of the film negative or by the size of a camera’s sensor. Enlargements are prone to film-grain very quickly; even large-format prints by artists such as Andreas Gursky (*99 Cent Store* is the size of a mural and currently the most expensive photographic ever sold at auction for a staggering \$3.3 million dollars) face the problem of limited resolution. What at first seems like a highly-detailed wall-sized photograph from a distance appears extremely granulated up close, with little to no ability to make out distinct details as the viewer approaches the image. In the very subjective world of fine-art photography, surpassing several photographic boundaries to make extremely

detailed, high-resolution, monumental photographs helps generate interest in an artist's work while also simultaneously granting that artist potentially unlimited design flexibility with regard to the final image.

Another photographic post-processing technique, High Dynamic Range imaging is sometimes used by Fine Art photographers to create an extremely vivid, hyper-realistic image. Commonly referred to as HDRi, the process has only been available since the advent of digital imaging technology, and consists of taking multiple exposures of a single image and then compressing those exposures tonally into a single, multi-exposure image. The technique is appealing not only because of the ability to photograph spaces that have often been troublesome for photographers, such as locations with extremely bright windows and dark subject matter, but also because the end result is usually a very highly saturated, almost dream-like image that resembles something closer to a drawing or painting—in which an artist has control over the final exposure values of certain areas of the picture plane and can consequently compensate for any differences using just his or her eyes. Many digital photographers have since experimented with and made the technique a specialty, often with visually stunning results. While the Gigapan.org online image database sometimes hosts gigapixel-resolution images that somewhat resemble HDRi (most of the time unintentionally- leaving the auto-exposure setting on digital cameras mimics the result), the combination of these two technologies, gigapixel imaging and HDRi, has proven to be a promising technology both within the gigapixel imaging community, the field of fine-art, and, unexpectedly, in the field of fashion design.

High Dynamic Range Gigapixel Processes

Early experimentation with the auto-bracketing feature available on most modern digital cameras automatically generates multiple exposures rapidly. The Gigapan robotic panoramic head as well as auto-bracketing allows a photographer to automatically generate a large-scale panoramic series of images at exposures at -2, 0, and +2 EV. By using the Gigapan Epic 100's robotic arm to depress the shutter release button, the camera automatically does the tedious work of resetting exposure at proper intervals based on shutter speed. Even though HDRi results are even more striking with six to nine individual exposures, (an auto-bracketing feature available on higher-end professional cameras, such as the Nikon D3), prosumer cameras such as the Nikon D90 can be automatically programmed to take series of three exposures sufficient enough for HDRi processes. The Gigapan panoramic head is an ideal platform to photograph large-scale HDRi panoramas because of its convenience and speed, as well as the ability to photograph images without user-intervention between shots. For this reason, using a robotic platform also has the added benefit of decreasing likelihood of both camera shake and movement between exposures.

While numerous panorama software packages, as well as numerous HDRi programs exist, the first challenge needing to be addressed is in dealing with a program robust enough to work with the processor-intensive resolution of gigapixel imagery as well as one that offers tone mapping capabilities (the specific name for the process in which HDRi images are generated). Tools such as AutoPano Pro Giga-- software specifically meant to deal with gigapixel panoramas that offer some new HDRi tools— exist specifically to assist with this process.

AutoPano Pro Giga deals with HDRi imagery by generating stitching 'control points' using a single panoramic exposure first, then automatically constructs the other exposures of the image by applying the exact same control points to additional panoramic source image sets. This differs from using a program such as Gigapan Stitcher, for instance, to generate all three gigapixel panoramas, as the software may misinterpret features of the differently-exposed panoramas, resulting in final images potentially radically different in final size. As a result, the separate panoramic images would not, in all likelihood, line up correctly when tone mapped in a third-party software application. That said, initial tests with HDR images in AutoPano Pro Giga prove that the software is somewhat buggy at times, especially with regard to its more advanced features; the software crashed before a single test was completed. Hardware used to perform the AutoPano Pro Giga included a custom-built 3.0 Gigahertz quad-core PC with 12 gigabytes of RAM running a stable version of Windows Vista 64-bit, so this was most likely not due to an equipment issue. Rather than trying to process the images on a much slower machine or try to find another high-end hardware alternative, it became necessary to experiment with other methods of generating HDR Gigapixel images.

As AutoPano Pro Giga is one of the few panoramic stitching programs that features HDRi processing, utilizing a tone mapping program that offers batch-processing of source images before stitching the gigapixel panorama allows for creation of an HDRi source image set in its' entirety prior to assembling a completed panoramic image. While assembling completed individual exposures for a single panorama would have been preferred in order to precisely tone map the results to yield the most aesthetically striking image, generating any amount of success with an HDR Gigapixel image potentially yielded the highest-resolution HDRi photograph taken to date. PhotoMatix Pro is a tone mapping program considered by many to be the industry standard for producing HDRi photographs because of its wide-array of features. PhotoMatix also has the distinction of being extremely fast at processing these images, and offers dynamic batch processing tools that automatically adjust for

any vertical and horizontal shifts between images, as well as using settings previously set by the user. By tone mapping a single image taken with three exposures and saving the settings, it is possible to batch-process an entire set of multiple-exposure source images with relatively automatic ease, generating consistent enough results to be used in a final, seamless gigapixel panorama.

Failures & Successes

The first HDRi panorama ever produced (arguably not a true gigapixel image though it comes close at around 890 megapixels and was in all likelihood still one of the largest created at the time) was one shot over the course of a June morning in 2009. The image itself is a view overlooking the bay of Miami towards the downtown skyline (*Figure 1*). The HDR Gigapixel post-processing techniques finally proved successful, if somewhat unremarkable, in that you can clearly make out detail in the clouds and vivid color saturation is present across the entire image. That said, the amount of HDRi artifacts (seen in the ‘ghosting’ of trucks driving on the highway at the time), let much to be desired. With regards to Fine Art Photography, exhibition was likely going to be in large-scale print format, so part of the experiment’s purpose was to ultimately create an aesthetically valuable image suitable enough for large-format printing, so the amount of manual retouching still necessary unfortunately makes HDR Gigapixel imaging a technology not conducive to capturing moving subject matter. That said, the image *Miami Skyline (HDR)* appears to have been licensed for use by third-party high-resolution image sources (albeit without explicit consent of the photographer) by Gigapan.org, as stated on their website.¹

The next attempt at an HDR Gigapixel photograph may potentially be the highest-resolution HDRi photograph ever created (though the claim was dismissed by the Guinness Book as being ‘too specialized’), and looks over the port of Miami (*Figure 2*). This was an image that, in the interest of experimentation, was reexamined and retouched manually; any objects that displayed ghosting artifacts were replaced with single-exposure portions of the source images then manipulated to match the final panoramic image. The result is a highly-saturated, artifact-free, HDRi Gigapixel-resolution photograph, and marks the culmination of the innovation of a relatively automated, rapid technique suitable for creating High Dynamic Range Gigapixel images.

APPLYING THE TECHNIQUE TO AESTHETICALLY VALUABLE SUBJECT MATTER

Perspective Issues & Aesthetics

The initial results, while noteworthy in their technical achievement, yielded little in the way of artistic or aesthetic merit. The subject matter used in the initial HDRi Gigapixel-resolution experiments, while typically visually appealing to the casual observer—especially when shown in striking ‘HDRi color’— simply do not seem to warrant the use of the HDRi technique (there are not necessarily huge differences in dynamic range when outside and shooting massive objects in bright sunlight). For all its promise, the HDRi technique also takes roughly three times as long to photograph an image, and probably two to three times as long to process because of the extra steps involved, if not longer, so having the proper vision and foresight to be able to choose appealing subject matter is clearly necessary to creating a photographic image with any aesthetic value. Additionally, the warped perspective that is a trademark of the Gigapan robotic head, as well as to multi-image stitched photographic panoramas in general, means that in HDRi Gigapixel images the largest subjects, such as the buildings on the opposite edge of a bay, actually end up being comparable, if not smaller, in relative size to the wooden platform the Gigapan head is photographing from. As a result, it becomes the photographer’s responsibility to perceive the potential image through a ‘360-degree viewfinder’; to ‘previsualize’ the spherical perception of a location when projected back on a two-dimensional surface.

Discovery of the Abandoned Pumping Station

One location potentially suitable for HDR Gigapixel Imaging because of its visually interesting interior as well as the juxtaposition of modern technology with seemingly disparate, antiquated subject matter (among other reasons more appropriate to an artistic statement, as opposed to scientific paper), is a decaying all-brick building incorrectly originally assumed to be a hydropower generating plant left over from the 1920s or so. The location had been vandalized by graffiti artists in the time between its decommissioning (as what is now understood to be a reservoir pumping station) and the present. Previous photographic film images of the location, developed on 8 x 10 photographic paper, produced visually striking results, if for no other reason than the photogenic appeal of the location itself. Also a potentially great place to experiment with HDRi specifically, the interior of the building is riddled with holes and exterior openings, and features extremely dark corners that barely receive any light. In fact, short of using the auto-exposure feature on a camera, one would be hard-pressed to conceive of a way to properly expose for a 360-degree shot in such a location without the use of HDRi.

After three separate trips over the course of an entire day (due to battery depletions in both the D90 as well as the Gigapan), usable 360-degree source images were finally obtained. The interior of the pumping station is a square room even on all sides, so in order to minimize uneven perspective distortion the camera was set up in as central a location in the room as possible. The source photographs were created using the 3-exposure auto-bracketing feature on a Nikon D90 set at -2.0, 0, and +2.0 EV, both at a fairly telephoto zoom-lens setting as well as at a wider zoom to allow for maximum post-processing ability as well as to compensate for any stitching errors that may have occurred due to nodal point misalignment.

The results, once processed, were immediately encouraging (*Figure 3, 3.1*). To determine the correct tone mapping preset to use, a single multi-exposure source photograph that shared a darker area of the interior space as well as a large, external opening was created. By experimenting with some of the tone mapping settings, settings were obtained that displayed the interior graffiti-covered brick walls as well as the forest preservation that surrounds the abandoned building (*Figure 3.2*). The vivid saturation of colors on the interior, painted walls as well as tonal compression of exterior and interior exposures portrayed accurate details in every area of the image—both the dark corners of the abandoned room as well as the exterior entrance and holes in the structure—and was precisely the reason the HDR Gigapixel imaging technique was developed in the first place.

Ultimately the final 35" x 90" rendition of the Abandoned Pumping Station image was arguably the first extreme-resolution HDRi archival print ever created (at around 500 megapixels, the shot is again not technically a true gigapixel-resolution photograph but certainly large enough resolution to print without discernable film grain at that size and an exceptional proof of concept) that demonstrated high-level aesthetic value while achieving the technical merit of the High Dynamic Range Gigapixel imaging technique previously developed.

Further Location & Subject Matter Research

Additional locations to photograph for appropriate subject matter using the High Dynamic Range Gigapixel imaging technique are difficult to find, simply because the artwork feature on them is often, including in the case of the Abandoned Pumping Station, exhibited in extremely hard-to-get-to, sometimes dangerous and often undisclosed areas. That said, the internet, as well as street art community networking and word-of-mouth proves one of some of the most valuable resources in searching out new locations. Likewise, the 'urban exploration', as it's commonly referred to, that goes into discovering graffiti-laden abandoned buildings, is usually challenging, though aesthetically overwhelming and rewarding in its own right.

Adventurous spirit aside, caution, preparation and tact are useful to keep in mind when exploring such off-the-beaten-path areas. One location, in particular, the 'Krome Avenue Penitentiary', near Hialeah, Florida (*Figure 4*), is usually used on weekends by paintball players, and so there is a fair chance that anyone wandering around that location (not to mention their photographic equipment) may be prone to paintball fire. In the case of the 'Krome Avenue Penitentiary', it is also noteworthy to state that although no 'No Trespassing' signs are posted, police have 'raided' the location; now, for the most part, the concrete military outpost formerly referred to as 'NIKE Missile Site HM-95' has been largely abandoned by the artists, paintball players, and vandals that once frequented the decomposing structure. Unlike the majority of gigapixel-resolution subject matter, in many cases it is generally a prudent idea to have at least one additional person accompanying the photographer, as well. The importance of researching such locations before attempting to photograph them is important not just in terms of finding additional proper subject matter, but also in the interest of preserving one's safety.

USE AND EXHIBITION OF HIGH DYNAMIC RANGE GIGAPIXEL IMAGES

Artistic Exhibition & Recognition

Submission of the print *Interior of an Abandoned Pumping Station near Millburn, NJ* to various Fine Art Photography competitions, as well as juried gallery shows, also proved highly rewarding. The first show to accept the work, an annual juried gallery show based out of Joplin, Missouri, *PhotoSpiva 2010* asserts itself as "the longest-running photographic competition of its kind in the U.S."², and took place between March 6 and April 25, 2010 (*Figure 5*). The print, one of 84 accepted out of over 900 submissions, consequently was one of seven submissions to win a Merit Award³. The image was again accepted, among others created using the same HDR Gigapixel imaging technique, into another annual show, *Still Point II*, which took place from April 7 – June 8, 2010, and can still be viewed online at the Still Point Gallery⁴. While the image did not receive any awards and was downgraded from original resolution to be suitable for the exhibition, the unique process and artistic statement for the project was featured on the *Still Point Blog*⁵.

Another article, written for the *Millburn-Short Hills Patch* in April, 2010⁶, detailed the initial creation of the Pumping Station image and the technology used to create it.

Application & Design in Digital Textile Manufacturing

Shortly after achieving moderate recognition for the initial High Dynamic Range images, work began to print the photographs onto fabric using available digital textile manufacturing processes, a method of textile production that allows for high-resolution photographic printing comparable to archival inkjet printing on a photographic paper medium. Development is underway to apply HDR Gigapixel images to textiles, specifically Polyester Spandex blends, for use in the high-end Women's Swimwear industry (*Figure 6*). Additional markets and applications, such as Sports Apparel (*Figure 7*) and Interior Design, also have appropriate speculative aesthetic design appeal, and offer resolution previously not found in such fields. Additionally, because of the extremely-high resolution of the source panorama, parts of the original image can be utilized and enlarged on a piece of clothing without any noticeable loss in resolution. This offers designers more flexible design options that can be utilized after the photograph has already been taken and created, rather than having to foresee a design and imagine it on a specific garment while on location.

Photographic Copyright with Regard to Commercial Application

With regards to the question of ownership of a particular piece of work, generally speaking, copyright initially extends protection to "the author or authors of the work."⁷ In the specific use of photography, it is widely accepted that a photographer owns the copyright to photographs created of a public place.

Accordingly, as these locations *are*, in fact, public places, the artwork on the walls is technically vandalism, and therefore constitutes criminal activity. As long as the images are not published by the photographer in any way that would jeopardize a person's right to their own private image, the images are in fair and usable legal territory.

Patent Protection

As this is understood to be the first instance that HDR Gigapixel source images have been used in a digital application to textiles, there is speculation that the novel process could enjoy patent protection as well, and development and submission of a patent application is underway. The process, as discussed above, allows for wide-reaching design flexibility and extremely high-quality print resolution on textiles previously unheard of in digital textile manufacturing, as well as in the fashion industry on the whole.

Furthermore, the fashion industry operates in a notoriously low-intellectual property right environment. This is because of the nature of the field itself; designers are keen to make new patterns (a term laymen would probably refer to as 'cuts') for their clothing, and accept that imitation is, to use the term, 'the highest form of flattery'. Cheap imitation brands of clothing in the fashion industry actually potentially add value to an original article and/or brand of clothing, bolstering the reputation and exclusivity of the designer (therefore allowing the original designer to, of course, price their garments higher than they usually would due to common rules of supply and demand).

As there is little in the way of patent protectable processes in the fashion industry aside innovative technological discoveries, patent protection is often seen as an extremely prestigious and exclusive mark for any brand and/or designer. The 'patent pending' denotation will differentiate an HDR Gigapixel-based brand from its current competitors and any potential imitators, helping to make the brand more exclusive as well as possibly deterring future competition.

At the same time, competitors could still market subject matter-specific imitations (which, in this case, would be Street Art/Graffiti-themed swimwear), though their design flexibility and ultimately print resolution, especially with regard to enlargement capabilities, would be extremely limited by their source photographs. Additionally, because of patent protection, any branding and marketing opportunities enjoyed by an HDR Gigapixel-based brand would of course not be able to be shared by a competitor as well.

CONCLUSION

Philosophical Implications of Eternalizing the Intentionally Temporary

Since an artist's work is about intention, it is worth noting that as the graffiti and urban art photographed for this project, specifically, often constitute vandalism (which should not be confused with the idea that street art in and of itself is a crime) and for that reason are also created with the idea in mind that the art itself will be destroyed, either through additional painting or destruction of the building itself. As such, part of the heritage and culture surrounding graffiti and street art is that, while it could be art that stands undisturbed indefinitely, it also could just exist for only a moment, and that artistic pieces that took hours, sometimes even days to create, could be destroyed in just a matter of hours.

By capturing these pieces in a relatively permanent medium, such as archival photographic prints or digitally printed apparel, the moment itself, the immediate state of what is basically communal canvas, is captured precisely in time. The use of High Dynamic Range Gigapixel imagery further reinforces this idea, in that the paint on the wall itself—down to the level of how it was actually applied, in some cases—can be reexamined visually in extreme detail at an undetermined time in the future, and is, in effect, ‘eternalized’. Furthermore, by applying these photographs to large-scale artistic prints and the entire world of fashion, urban artwork first intentionally created with no necessary goal of exhibition or longevity outside of an underground, relatively small group of people, has been brought to the attention of a much larger-scale audience, repurposed as artifacts with artistic merit and historical value in their own right.

FIGURES



Figure 1. *Miami Skyline (HDR)*. Most likely the first near-gigapixel resolution high dynamic range image produced. For zoomable version, see <http://gigapan.org/gigapans/25008/>.



Figure 2. *Port of Miami, Miami, Florida.* Arguably the largest high dynamic range photograph ever taken, at 2.71 Gigapixels. For zoomable version, see <http://gigapan.org/gigapans/25183/>.



Figure 3. *Interior of an Abandoned Pumping Station near Millburn, NJ.* For zoomable version, see <http://gigapan.org/gigapans/38060/>.



Figure 3.1. Snapshot showing detail. For more, see <http://gigapan.org/gigapans/38060/snapshots/111086/>.



Figure 3.2. Consistent exposure between interior and exterior spaces.



Figure 4. Nike Missile Site HM-95 (Camp Krome) #1, 3/19/2010. For zoomable version, see <http://gigapan.org/gigapans/45127/>.



Figure 5. The Abandoned Pumping Station image on exhibition at *PhotoSpiva 2010*, March 6 – April 25, 2010. For more images, see <http://cineflock.blogspot.com/2010/03/jay-hirschfeld-awarded-merit-award-in.html>.



Figure 6. Conceptual photograph of the Abandoned Pumping Station image on women's swimwear.



Figure 7. The Abandoned Pumping Station image digitally printed on cycling apparel.

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