Complete HDR tutorial

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http://hdrphotographer.blogspot.com/
Note: This is a revised version of the tutorial I have posted a few years back on my blog. This version details the HDR processing much more and gives more examples. This version is also updated for Photomatix Pro 5.0.

Note 2: If you like this tutorial, please share the link to it so more people can read it.

Note 3: Make sure to visit my blog to learn more about HDR photography and view my photos: http://hdrphotographer.blogspot.com/
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INTRODUCTION

ABOUT THIS TUTORIAL

In this tutorial I will try to introduce and describe HDR photography in-depth. I will try to answer following questions:

- What HDR photography really is?
- How to take HDR photos?
- How to process HDR photos?

I will also talk about typical problems related to this kind of photography and I will propose solutions on getting rid of them. I will also try to share my own ideas about work-flow and post-processing which I use in my daily post-processing. It means that I will write mostly about realistic HDR photos.

Moreover I'll share a bunch of sample HDR photos to get you inspired (and hopefully to keep you interested as you read this tutorial).

In the first part, which you are currently reading, I will talk a bit about HDR photography theory and software. I will show you why HDR is sometimes necessary and what its advantages are. I will also tell you how to take a HDR photo and finally I will also talk about typical problems you might encounter when dealing with HDR photos.

In the second part, Realistic Workflow in Photomatix Pro, I will guide you through the interface of Photomatix Pro 5 showing you how to create your HDR image, deghost it and finally tone-map it.

In the next parts I will talk about various creative approaches and techniques. In Black & White HDR I will give you a few tips on creating black & white HDR images. Multiple Tone-Mapping section describes how to tone-map same image several times for creative effects and Exposure Fusion section deals with alternative approach to HDR that produces ultra-looking images.

Then, next few sections are appendixes that you might find interesting even if you are using Photomatix Pro or at least create HDR images for some time.

Finally, if you’re interested in HDR photography make sure to visit my blog, where you can learn more about it and download free photography resources (like Photomatix Pro and Lightroom presets): http://hdrphotographer.blogspot.com/

I hope you will like it,

Wojciech Toman
WHAT IS HDR?

Many people have a wrong idea about what HDR photography really is. HDR, which stands for High Dynamic Range (what means nothing more but wide range of luminosity and contrast in the scene), is neither a special effect nor a post-processing technique. Remember that.

HDR is reality, it is what we see every day but what isn’t captured properly by our cameras. HDR we use in photography is sort of a trick to overcome limitations of current generations of cameras and display devices. Although I don’t think grunge or overdone HDR photos are always a bad thing (provided it was done on purpose not because of lack of skills in realistic HDR processing) many of the beginners cannot really feel the concept of HDR and their images are full of artifacts like halos, noise and ghosting to name a few (all of them will be described later, so don’t worry if you don’t know what I’m talking about here).

HDR (High Dynamic Range) photo has much more information about luminosity than a Low Dynamic Range photo (like a single JPG, TIFF). Luminosity is a characteristic we relate to light, not colour. It does have nothing with colour temperature or saturation. That’s why I said HDR is not a special effect. Light is something that surrounds us. Dealing with it can’t be thought as special effect.
Now it's time for some examples. HDR is trying to solve a following problem. The real-life scene can have contrast of 100,000:1 or even higher. This ratio tells the difference between the brightest (eg. the Sun) and the darkest (eg. deep shadow of a tree) point of that scene. Sometimes the contrast is so high that even our own eyes aren't capable of showing it all and we perceive parts of the scene as very dark or very bright. Just move from a very dark room outside where the sunlight is very strong. At first everything is almost white and faded then colours become to look normal but look back and everything will be dark, almost black. It's because our eyes have dynamic range of only about 10,000:1 meaning that we can't see details in shadows and lights at the same time.
Another example might be a forest with some beautiful light and shadows play, with a lot of dark places and light shafts going through the leaves. Or yet another - a cave. You can try shooting outdoors from inside. In both cases our camera fails - it cannot recognize enough details both in highlights and shadows no matter what its dynamic range is (our cameras have much worse dynamic range than our eyes in fact). And even if it could there is no display device capable of properly displaying such a photo. Who know, maybe one day it will be possible but not yet. Regarding camera's dynamic range, eg. my Canon 5D MK III has dynamic range of about 2.000:1... not really good.

Take a look at the photo on the next page to understand better what I’m talking about here. Left part was exposed for the sky. You can see beautiful clouds there but shadows in the forest are very dark, almost black. I could brighten them up but they would contain a lot of noise. Way too much noise to be useful. On the other hand image on the right was exposed for water and the forest and they look nice this time. However, the drawback is that those beautiful clouds are completely blown out.
Without HDR I would end up with an image that is correctly exposed either for the sky or water and forest. Without HDR I wouldn’t be able to get correct exposure across whole frame.

This leads to a conclusion that HDR is in fact a trick, something allowing us to overcome limitations of current devices. It uses photo with much wider luminosity range and it maps it back to the space which is possible to be displayed on our monitors.

But you maybe also know that it isn’t possible to display a real HDR photo on a typical monitor without a special conversion step known as tone-mapping. Primary purpose of tone-mapping is limiting luminosity of HDR image so it fits in the range that monitor is capable of displaying correctly. Tone-mapped image IS NOT HDR image anymore. It becomes LDR image (Low Dynamic Range). It means that using a term HDR photos for images that were tone-mapped isn’t correct.

That said what you should primarily use tone-mapping for is making sure that details both in highlights and shadows are correctly preserved. You don’t need to care about colour temperature or saturation at this stage that much (although you should correct them were they wrong). Also there are virtually infinite ways of tone-mapping as you may guess (as
there is infinite number of functions mapping from the wide-range to the low-range) photo but all algorithms (known as operators) fall into one of the two categories:

- **Local operators** (i.e. in a small neighbourhood of a pixel) - they are working on the local features of the image. It means that tone-mapping might work differently for each pixel of the image depending on characteristics of its surrounding. Local operators are commonly used in HDR software because they produce more appealing images with details and micro-contrast being well enhanced. However, local tone-mapping operators have a few drawbacks. First of all they can amplify noise in the image as software cannot always determine if something is just noise or very small detail so it might treat it as detail. When small details are enhanced, so is the noise. Tone-mapping is no exception here. Many sharpening tools must deal with the same issue. Another issue with local tone-mapping operators is they can produce halo artifacts around the edges.

- **Global operators** - each pixel is tone-mapped in the same way based on some global image characteristics (like eg. luminosity). As you may have guessed this makes these kind of methods really fast (that’s one of the reasons they are used in video games more commonly than local operators) but there might be some loss of detail. The greater the dynamic range of the source image the greater loss of detail is possible.

As mentioned above the main advantage of the global tone-mapping operators is their speed. It is enough to say that global operators are much more frequently used in real-time scenarios (like video games) but local operators produce much more appealing results as they enhance details and contrast locally taking more characteristics into account. That’s why we, photographers, use them more commonly than global ones.
TAKING A HDR PHOTO

I mentioned that today’s cameras aren’t capable of capturing real-life scene’s dynamic range so the question is how to take a HDR photo?

We have to use a simple trick here. Instead of taking a single exposure with very limited dynamic range we take 2, 3, 5 or more each of them differently exposed (some darker, some brighter than “correct” exposure). Then this photos would be merged into one in the “merge to HDR process. The resulting photo will have depth of 96 bits (32-bits per channel) so it has much more data about scene luminosity than any of the source images.

Number of photos required to cover dynamic range of a scene varies from scene to scene. However, those photos should cover as much luminosity as possible from the brightest to the darkest parts of the frame. Sometimes it’s enough to take 1 photo (yes! Sometimes there is no need to bracket at all), sometimes 3 photos will do, sometimes, 5, 7 or even more. Of course number of photos depend on the EV spacing between the shots of the sequence but most popular steps are 1.0, 1.5, 2.0 EV.
Ok, so you might ask whether you should choose 1.0, 1.5 or 2.0 EV spacing? Generally speaking using 1 EV gives smoothest tonal gradations. But as stated above it requires twice as many shots as using 2 EV spacing - so the answer is - it depends.

Below there is a table with some of the most common types of scenes and number of exposures needed to properly capture them when using 2 EV spacing:

<table>
<thead>
<tr>
<th>Scene Type</th>
<th>Number of exposures needed</th>
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<tr>
<td>Landscape on foggy day</td>
<td>1 to 3</td>
</tr>
<tr>
<td>Landscape with clear sky</td>
<td>3</td>
</tr>
<tr>
<td>Landscape with some clouds</td>
<td>3 to 5</td>
</tr>
<tr>
<td>Landscape with overcast sky</td>
<td>3</td>
</tr>
<tr>
<td>Sunset/Sunrise</td>
<td>3 to 5 (7 in extreme cases)</td>
</tr>
<tr>
<td>Forest on sunny days</td>
<td>5 or more</td>
</tr>
<tr>
<td>Interior photos without windows</td>
<td>3</td>
</tr>
<tr>
<td>Interior photos with windows</td>
<td>7 or more</td>
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Odd number of photos is used most frequently as this way we have equal number of photos for shadows and highlights and one more for "mid-tones". For 5 photos, this situation is depicted on the image below:

As you can see from above image, to get details in shadows it is necessary to use positive exposure compensations (eg. +2 EV, +4 EV) meaning that it is necessary to overexpose a photo. To get details in highlights it is necessary to use negative compensation in turn (eg. -2 EV, -4 EV) i.e. to take underexposed shot.

For most scene types 3 photos are sufficient and then:

- 1 goes for mid-tones,
- 1 goes for correctly exposing the shadows (by this I mean that this photo will reveal details in shadows),
- 1 goes for correctly exposing the highlights (this photo will be used to save highlights).

The highest number of photos is required in case of very high contrast scenes like, eg.:  

- Sunsets and sunrises,
- Forests with deep shadows and light shafts,
- Indoors there are windows or doors,

It is important to understand that “the more photos, the better” approach isn’t always good because:

- The more photos are taken, the longer it takes to shoot them all. It can lead to noticeable differences between the first and the last photo of the sequence caused by movement in the scene (wind, movement of people and vehicles) what can lead to artifacts known as ghosts.
- There might be no visual difference between 5 and 50 photos (if 5 photos are sufficient to cover dynamic range of the scene; 50 won’t make it any better). In this case it’s even possible that image quality will be degraded due to ghosting artifacts mentioned in the previous point. Besides the more photos, the more memory is required to process them and the more time it takes (50 photos would require a lot of memory - believe me :) ).
- When shooting hand-held it is very difficult to take more than 3 shots and have them properly aligned.

Taking right number of photos is very important as when there are too few photos then noise in the final shot can become more prominent. As a rule of thumb remember that your most overexposed photo (which is used to recover details from shadows) should have shadows in the midtones area of histogram.

As already mentioned these photos are then merged into HDR photo i.e. into a photo having much wider dynamic range than input images. In Photomatix Pro and a number of other applications it’s all about loading whole sequence and the merging process is fully automatic (although we still have opportunity of setting some options to influence it).

Although bracketed shots give best results in most cases (unless one photo covers whole dynamic range of the scene), Photomatix Pro and other applications allow user to load and tone map a single photo. It doesn’t even need to be RAW. It can be both 16- and 8-bit TIFF or even JPEG file. The benefit of using a single exposure is that it allows us to shoot handheld and eliminates a problem of ghosts completely. Of course it won’t be a real HDR photo but the results are often still quite good. Below is example photo taken in Lisbon and tonemapped from a single file:
I myself take 5 to 7 bracketed photos most of the time. Very rarely I take more. This allows me to use auto-bracketing feature of my DSLR which is a really neat feature (unfortunately almost all Canon cameras can only shoot 3 photos in the auto-bracketing mode. It’s much better for owners of Nikon). Although auto-bracketing was invented for other purpose (namely increasing the chance of taking correctly exposed photo in difficult light situations) it works fantastic with HDR photography. I also use burst mode which slightly decreases time between shots in the sequence and is also very important in case of shooting handheld (I will tell more about it in a second).

I start taking bracketed photos by finding the right exposure for the middle photo, i.e. the one I would use if I wouldn’t take HDR photo. It is especially important when taking photo of very difficult scenes like beach or snow because to get good photo exposure biasing might be necessary to used. Then I take photos in a sequence using 1 EV step (sometimes 1.5 EV). As mentioned above I take 5 to 7 exposures most of the time but you have to
remember that in many cases 3 will be enough (but I often shoot in difficult lighting conditions.

It is important to notice that bracketed photos have to be taken in one of 2 manual modes:

- Aperture Priority (Av, A),
- Fully manual (M).

Why? The answer is quite simple, we have to be able to change exposure between the consecutive shots of the sequence. However, we want to change exposure time only. Changing aperture instead could result in some bad results due to large differences in depth of field. Changing ISO in turn could result in larger noise in some photos.
Now we know more less what HDR photography is.

We now also know that we need some tool to create HDR image from bracketed photos and to tone-map it. At the moment there are a lot of options here, each of the programs offers slightly different capabilities and has different tone-mapping algorithms what results in slightly different output (that’s why many photographers own more than one application). Also some applications deal better with particular scenes than the others but fail at some other scenes. Below I listed a few most popular programs:

- **HDRsoft Photomatix Pro** - one of the most popular HDR software available on the market. I use Photomatix Pro to create all my HDR photos.
- **Nik Software HDR Effex Pro** - software from Nik company working as a Photoshop plugin. It uses Nik’s typical GUI and U Point technology.
- **Adobe Photoshop CS5/CS6/CC** - for a few years now Photoshop has HDR plugin available out-of-the-box. Even though there was pretty big improvement in CS5 it is still considered worse from dedicated software.
- **Olloneo**.
Personally for all my HDR photos I use Photomatix Pro 5.0 (+ Lightroom + Photoshop + Topaz plug-ins for final tweaks) and this is a program on which I’m focusing in this tutorial. However, many concepts and ideas can be used in other applications too.

Also if you don’t have Photomatix Pro but would like to follow what I’m doing you can download free trial of it from HDRsoft website. Note that trial never expires but it will add watermark to your tone-mapped and fused images.

There is also Photomatix Essentials (formerly known as Photomatix Light) - now in version 3.2 - which is slightly easier to use for beginners yet it uses the same algorithms as the Photomatix Pro version so you can achieve similar results with both applications.

**ISSUES**

HDR photography is unfortunately rather infamous for a few issues present in many photos. Thanks to them a lot of people assume that each HDR photo has them. However, all these issues can be quite easily solved and the fact they are present in many photos is due to mistakes done by photographers, not due to HDR photography itself.
Below I just name the problems and give short description to each of them. You will find more comprehensive description on how to get rid of each of them in further parts of this tutorial (eg. when describing settings I use for tone-mapping).

Noise

Concerning issues the first big one is noise. If we use local tone-mapping operators (like Details Enhancer in Photomatix Pro for instance) it is essential to pay extra attention to this. As local tone-mapping operators enhance local details they will enhance noise at the same time (as there is no way to distinguish between noise and a very detailed texture). To prevent this do following:

- Cover whole dynamic range of the scene. If there will be enough information about shadows than noise won’t be prominent. It means that if the brightest photo in the scene doesn’t lit shadows enough then noise from it will be transferred to the final image.
- Use low ISO values whenever possible. But it doesn’t mean lowest values as in some cases ISO 50 or ISO 100 can have more noise than ISO 200. Check your camera lowest native ISO.

Misalignment

Next thing is vertical and horizontal movement between the shots of the bracketed sequence. This can cause issues with photo alignment.

To minimize this movement it is good idea to use a sturdy tripod and to use remote shutter release (through a cable or pilot). However, many of my shots are taken hand-held at 10 mm (16 mm equivalent) or 24 mm and the movement is really hard to notice.

Oversaturated look

One of the common mistakes is that Saturation setting in Photomatix Pro is set to relatively high value. This makes colors to have this grunge or surreal look - they scream HDR making photo look very unrealistic! In case of Details Enhancer, for Saturation I use values in range 40 - 50 and for other processing method I usually use default values.

You have to be aware that in case of Details Enhancer this slider is a bit different than Saturation in eg. Lightroom or Photoshop in a sense that other settings affect its behaviour, eg. using lower value for Strength allows you to use higher values for Saturation. Using higher values for Strength in turn requires reducing Saturation to keep the realistic look.

Another thing is that particular colors (especially reds and greens) might still look oversaturated despite using rather low Saturation value in Photomatix. The fix is very easy. You can use Finishing Touch in Photomatix or Saturation sliders in Lightroom (or Hue/Saturation Adjustment Layer in Photoshop CS) to decrease saturation of these particular colors.
Here is example photo. The blues in the sky and reds of the tram are very unnatural in this case. In this case I would slightly decrease both Vibrance and Saturation in Lightroom after processing my image in Photomatix Pro.
Halo artifacts

It's the most common mistake, made especially by beginners. It's about leaving halo artifacts around the edges. It's visible mostly on the boundary of two regions with very different brightness (eg. between bright sky and dark forest).

For Details Enhancer you can fix this in many ways: decrease Strength, decrease Lighting Adjustments setting to Natural or Natural+, increase Smooth Highlights. You might also want to use combination of these to achieve halo-free results. Another fix is to use burn and dodge tools in Photoshop but I always try to fix it in Photomatix.

Also in Photomatix Pro 5.0 you can use Contrast Optimizer. Most of the time it produces halo-free images out of the box.

Here is example of this issue created when using Surreal preset from Photomatix Pro 5.0:
Ghosts

The last issue I would like to mention here are ghosts. Similarly to misalignment issue mentioned earlier they are also caused by movement but contrary to problems with alignment ghosts are caused by the subjects moving between shots: people can walk a few meters, the grass blades are waving, the water is flowing... the movement is everywhere! You just can’t say: *Hey world! Stop for a second - I’m taking a HDR photo*. You would be ignored.

In the photo below you can see some ghosting artifacts: take a look especially at the car in the left of the image and people in the right. These are ghosts.

I will describe how to deal with this particular issue a bit later in this tutorial - Photomatix Pro offers some great and very effective ways of dealing with them.
REALISTIC WORKFLOW IN PHOTOMATIX PRO

At this stage you should more less understand what HDR really is and what we will try to achieve. So in this section I will show you how to use Photomatix Pro to load and process photos in it.
LOADING BRACKETED PHOTOS

After starting up Photomatix Pro the first step is to load our bracketed photos. We can do this by either:

1. Clicking on the Load Bracketed Photos button - top one in the Workflow Shortcuts window,
2. Pressing CTRL + L keyboard shortcut (CMD + L on Mac),
3. Using File -> Load Bracketed Photos... menu,
4. Dragging the photos to the Photomatix Pro from Windows Explorer (or Adobe Bridge for instance).

If you own Adobe Lightroom you can also install a plugin which comes with Photomatix Pro. Then you will be able to export bracketed photos directly from Lightroom. Just select bracketed files in the library, right-click -> Export To -> Photomatix Pro.

Then following window will appear:
IMG_1339.CR2 to IMG_1338.CR2 in the screenshot above are names of RAW photos from a bracketed sequence taken by me. I used Browse button to load them all. In case you would like to remove a photo from the list, just select it and click on the Remove button.

Also note Show 32-bit unprocessed image checkbox. I have it checked almost all the time. This instructs Photomatix Pro to show you a merged HDR photo before actually tone-mapping it. One of the benefits is that you can save this HDR photo and process it again whenever you want to (with different settings perhaps). This saves a lot of time because merging to HDR can be a pretty time-consuming process (especially when using long sequences like the above one, large RAW files and using options like alignment and deghosting).

After clicking on the OK button another dialog is shown:
In this step we can decide how the photos will be merged into HDR photo. There are quite a lot of options here including alignment, deghosting and white balance amongst others:

- **Align source images** — this option enables alignment of photo which are misaligned (due to handshake or tripod shake):
  - *Taken on tripod* - this option is much faster but it should be used only for the photos taken from a tripod.
  - *Hand-held* - this option is much slower yet it is very useful when photos were shot hand-held as it tries to match the features in the source photos. I also often use it even for photos taken on tripod.
  - *Crop aligned images* - if you check this option output image dimensions might be slightly smaller than source images size. It’s because Photomatix will crop parts that couldn’t be aligned (because they existed only in one photo for instance).

- **Show options to remove ghosts** - do you remember ghost artifacts I mentioned in the Issues section, well this option enables deghosting algorithm which removes artifacts caused by the subjects which moved across photos of the bracketed sequence. It is important to notice that this option should be disabled when there is no ghosting artifacts in the image as it can slightly degrade image quality (compare it to using Image Stabilization on a tripod).

- **Reduce noise on** - enables advanced noise reduction algorithm. In the combobox to the right of this checkbox you can select on which photos denoising will be run.

- **Reduce chromatic aberrations** - enables chromatic aberration reduction algorithm.

- **White Balance** - white balance (available only for RAW photos).
• *Color primaries based on* - color space (available only for RAW photos). You can choose from sRGB, Adobe RGB and ProPhoto.

**GHOSTS REMOVAL**

If in the previous step *Show options to remove ghosts* was checked now you will be presented with tool allowing you to remove ghosts.
In the top left corner you can select deghosting mode:

- **Selective Deghosting** - powerful tool that allows you to select regions that are ghosted using lasso tool and mark them as ghosts.
- **Automatic Deghosting** - tool that was greatly improved in Photomatix Pro 5.0. You can specify strength and base photo used by deghosting and it will automatically attempt to remove any ghosts in your image.

Whatever mode you will select (they are described just below) once you're done click on the **OK** button to proceed. Both modes share a few GUI elements:

- **Preview image** - shows effect of deghosting and lets you compare deghosting with the original image.
- **Brightness slider** - allows you to brighten the preview image so it's easier to see effect of deghosting. Note that changing this value doesn't affect your HDR image in any way - it's exposure won't change.
- **Zoom** - you can zoom in to see more details or zoom out to see whole image.
Selective Deghosting mode

Selective Deghosting mode in Photomatix Pro is about selecting ghosted regions by drawing selections around them using lasso tool and then replacing these regions with one of the source images.

After selecting with a lasso tool the region will be surrounded with dashed line:
Next right-click on the selected region and select *Mark selection as ghosted area* item as shown in the image below:

After marking the region as ghosted its border will become solid and option to select source photo to replace this ghosted region will become available after right-clicking this region.
At any time you can preview ghost removal by clicking on the *Preview Deghosting* button in the left side of the window.

Also small advice. If *Quick selection mode* box is checked, you won’t need to mark region as ghosted after drawing it with lasso tool - as soon as you release mouse button, region will be already marked as ghosted.

Click *OK* button to accept your changes and move to the next step.
Automatic Deghosting mode

Now onto another mode - **Automatic Deghosting**.

As it was said earlier this mode tries to remove ghosts automatically. As soon as you switch to it you will notice that interface changes a little bit:

*Deghosting* slider allows you to specify strength of deghosting. By default it's set to *None*. As soon as you start moving this slider you will notice that ghosts start to disappear. Now the thing is that moving the slider too far might in fact introduce new artifacts. It's because deghosting algorithm might detect that something is ghost while it might not be one. So my advice is to try avoiding maximum values most of the time. If you need very high values of *Deghosting*, I would suggest using **Selective Deghosting** instead.

Under *Deghosting* slider there is a list of all your images. The image which is selected is used as a *Base Photo* by deghosting algorithm. It means that any ghosts found will be replaced with pixels from that image.

And finally *Preview Deghosting* checkbox allows you to see your original image. This makes it easier to compare what effect deghosting has on your image. Just uncheck it to see *before*, and check it again to see *after*. 
MERGED HDR PHOTO

When Show 32-bit unprocessed image in „Load Bracketed Photos“ dialog was checked Photomatix Pro will show it at this stage:

At this stage the photo doesn’t look quite good as it's full of very deep shadows and overexposed areas at the same time. But this is true HDR photo - your monitor simply cannot display it, however, so it shows only the part of the available exposure. You can use F11 key to decrease preview exposure and F12 to increase it.

At this stage you can use File -> Save to save this unprocessed 32-bit image to EXR, HDR or floating-point TIFF file. This is especially useful if you want to process your photos in some other application supporting this formats or want to go back to this photo later in Photomatix Pro (I do this often when I think that I will use several different settings on a given photo).


**TONE-MAPPING STEP**

So click on the *Tone Map / Fuse* button to go to the tone-mapping tool. Thanks to tone-mapping we can map our high dynamic range photo to limited capabilities of a monitor.

**Graphical user interface**

The graphical user interface of the tone-mapping step looks as shown below:

Below all sections of GUI are briefly described:

1. Panel with choice of processing method. Photomatix Pro offers several different methods of processing photos:
   - *Details Enhancer* - local tone mapping operator that can be used for any look ranging from realistic to artistic or surreal,
   - *Contrast Optimizer* - local tone mapping operator that produces very natural looking images.
   - *Tone Compressor* - global tone mapping operator,
   - *Exposure Fusion* - fusion of input photos. Exposure fusion is not tone mapping operator nor does it produce HDR! Exposure fusion is technique of blending input photos by taking best pixels from each of them (based
on some rank) and outputting it in the final result. Photomatix Pro 4.2 offers following exposure fusion algorithms:

- **Natural**,  
- **Real-Estate**,  
- **Intensive**,  
- **2 Images**,  
- **Auto**,  
- **Average**.

Nowadays most of the time I use **Contrast Optimizer** or **Fusion/Real-Estate** for landscape photography, **Details Enhancer** or **Fusion/Real-Estate** for detailed interiors and **Fusion/Natural** for night photography. I sometimes use **Tone Compressor** for portraits.

Why do I use **Tone Compressor** for portraits? Because **Details Enhancer** enhances local details and contrast. So it enhances details also in the skin which is better to remain smooth. Otherwise the model looks as having serious skin diseases and the photo won’t be liked by him or her. However, **Details Enhancer** is very useful in enhancing eyes to add them some extra depth and magic. To do this multiple tone-mapping should be used which I will describe in a while.

2. Settings sliders and buttons allowing changing the look of the image. Number and type of the sliders depend on the selected processing method. **Details Enhancer** have the largest number of them.

3. Additional settings controls:

- **Method Defaults** button restores sliders to defaults of a method selected in point 1. For instance if you have Details Enhancer selected clicking this button will revert settings to **Default** preset and to **Balanced** preset in case of **Contrast Optimizer**.
- **Undo** and **Redo** buttons allow you to undo and redo last change of settings. As the history of changes is saved you can go back quite a few steps.
- **Preset** combobox allows you to select a preset, save or load one from disk.

4. **Apply** button. When you consider your image finished, click this button to process the photo. Then you will be able to save it.

5. Contextual help displaying short text about slider over which mouse pointer is currently placed. If you’re not sure what a given option is for, just move your mouse over it to see helpful description.

6. Zoom controls allow you to zoom in and out your preview image:

- **Scaling** slider is a fast method of increasing/decreasing magnification but it only upsamples/downsamples preview image so quality might be not always best.
- **Magnification** buttons allow you to change zoom level at which preview image is displayed. Changing magnification requires refreshing the image but the preview is more accurate than when using **Scaling** slider.
- **Fit** button will change zoom level of preview image in such a way that it occupies whole available space and yet no scrollbars are shown.
7. **Preview checkbox** - uncheck it to see your original image. It's a good way to compare your original image with tone-mapped one.

7. **Preview window** - the preview window shows how the final image will look. Preview is already tone-mapped (or fused) so it looks much better than HDR photo you saw earlier in this tutorial.

8. **Histogram** for currently displayed preview.

9. **Presets window**. Photomatix Pro offers dozens of ready to use presets out of the box. At the top of this window you will see following controls:

   - Combo box on the left is a category filter. It offers a lot of options like *Realistic, Artistic* or *Black & White* that will narrow the presets number and will show you only the ones that might be interesting to you.

   - This button allows you to select size of presets thumbnails. Clicking on it will toggle between large and small thumbnail size. In fact I already used large thumbnails in this screenshot.

   - This button allows you to toggle between one- and two-column view for presets thumbnails. By default only one column is shown but by clicking on this button you can see presets in two columns and thus to see many more presets at once without the need to use scrollbar.

At the bottom of this window there are two tabs:

- **Built-In** - it shows all presets that come with installation of Photomatix Pro.
- **My Presets** - presets that you saved or downloaded from the Internet. If you need some presets make sure to give my free presets collection a try. It features about 70 presets that can be used for all kind of HDR photos ranging from landscape to architecture.
Tone-mapping settings

As I already mentioned I use Details Enhancer and Contrast Optimizer quite a lot. As you might remember from the beginning of this tutorial I use Photomatix Pro mainly to preserve details in highlights and shadows as much as possible. At this stage I’m not thinking that much about colour but rather light and detail.

In the next two sections you will find settings I use most of the time for Details Enhancer and Contrast Optimizer together with short description of each setting.

Details Enhancer

- Basic options:
  - Strength - controls degree of detail and contrast enhancements in the image. Most of the time I use values in the range of 50 - 70. Sometimes I may go beyond 70 but in such a case I lower other settings. Using very large values might result in halo artifacts appearing in the image.
  - Color saturation - controls saturation and vibrance of colours. Most of the time I use 46, which is default value.
  - Tone compression - controls global luminosity level. Most of the time I use 0.
  - Detail contrast - this setting is responsible for enhancing contrast in local details (extremely useful when there are some detailed textures in the picture). I usually use values ranging from 5 to 10 because I like to enhance contrast a little bit.
  - Lighting Adjustments - one of the most important sliders in Photomatix Pro. It controls the general look of the image: natural vs. surreal. Using anything else than Natural+ (or Natural) might result in a very grungy and surreal look with a lot of halo artifacts.

- Additional options (More Options section):
  - Smooth Highlights - this setting lets you smooth the highlights in the photo. It’s especially useful if you have large areas of blue sky in your shot which often contains a lot of noise. Also use it when you want to prevent white highlights from becoming grey. I use values in range 0 – 20.
  - White Point - allows to set white point. Most of the time I lower it quite a lot to around 0.002% - 0.01%.
  - Black Point - allows to set black point. Most of the time I don’t change it.
  - Gamma – gamma… what to add here. Most of the times I use default value.
  - Temperature - colour temperature of the photo. Most of the time I don’t change it at all (because I prefer to do this in post) but when I do I use values between 0.0 and 4.0. I don’t use higher values as I find them too warm. Values lower than 0.0 I use rarely even in case of snow and ice.
Advanced options (Advanced Options section):

- **Microsmoothing** - is responsible for smoothing the enhancements done by local details enhancement. One of the effects is that it reduces noise (e.g. in the sky). Most often I use default 2.0 value. When I have a lot of tiny details or grain (like snow or sand) I use much lower values like 0.5 – 1.0. For some grainy images I use values around 4 - 5.

- **Saturation Highlights** - controls saturation of highlights areas without affecting saturation of shadows. I often use default value. Sometimes positive (like 1.0).

- **Saturation Shadows** - controls saturation of shadows areas without affecting saturation of highlights. I often use default value. Sometimes negative (like eg. -1.0).

- **Shadows Smoothness** - reduces contrast enhancements in the shadows. The only setting I’ve never ever changed from its default value.

- **Shadows Clipping** - this setting is especially useful when dealing with noise in the shadows as it clips them. Most of the time I use default 0 value. Sometimes, however, I can increase it even to 20 or more if I have very noisy images.
Contrast Optimizer became my favourite tone-mapper available in Photomatix Pro 5.0 very quickly. I love its natural and clean results. What's more default settings work well for me of the time and the only sliders I change are usually White Clip and Black Clip.

- **Strength** - amount of enhancement given to contrast and detail.
- **Tone Compression** - controls dynamic range of the image.
- **Lighting Effect** - move this slider to the right to brighten up the shadows and thus make the image look more surreal.
- **White Clip** - tells how much highlights will be clipped. I often reduce this slider, looking at the histogram at the same time, to avoid to much highlights to be clipped.
- **Black Clip** - tells how much shadows will be clipped. Most of the time I use values close to 0.
- **Midtone** - controls brightness of midtones.
- **Color Saturation** - saturation of colours in tone-mapped image.
- **Color Temperature** - temperature of colours in tone-mapped image.

**FINISHING AND SAVING**

After clicking **Apply** button, final tone-mapped image will appear:

Now you can save it by going to **File -> Save As** menu (or clicking CTRL + S on Windows or CMD + S on Mac) where you can specify output file name and format (jpg or tiff).

But wait a second - did you notice this very **Finishing Touch** window in the screen above? As it was stated several times in this tutorial tone-mapping is just a beginning. During tone-mapping phase we wanted to preserve details in highlights and shadows. Now it's time to enhance colours and global contrast of the image.

If you do not own any photo editing application there is good news for you - since Photomatix Pro 4.2 it is possible to do basic fine tuning directly inside Photomatix Pro -
using this *Finishing Touch* window! By default this window appears after you click on the *Apply* button (as in our case) but you can also open it manually by clicking on the *Utilities* -> *Finishing Touch* menu item. Let's take a closer look at this dialog:

There are 3 types of adjustments you can make:

- Contrast (*Contrast* tab),
- Color saturation (*Color* tab),
- Sharpening (*Sharpening* tab).

They work similar to the tools with same names in Lightroom, Photoshop or GIMP. You just drag slider and preview image is updated to reflect that change. Also the names should be pretty self-explanatory.
ADJUSTMENTS I MAKE

In this section I will describe typical adjustments I make to a photo processed in Photomatix.

1. I start my adjustments by importing a photo processed in Photomatix Pho and then I adjust following settings in Lightroom:
   - Vibrance (I often decide to reduce it to the value between -5 to -20),
   - Clarity (I often increase it to a value between 15 and 50),
   - Contrast (just a little bit at this stage),
   - Highlights and Shadows (to restore them).
2. If necessary I also correct colour balance at this step (especially greens as I have some problems capturing them properly or when I want warmer look for sunrises or sunsets). I often use presets at this step to make my work faster.
3. Export image to Photoshop... and now the real fun begins :) Yeah, I’m a great fan of Photoshop. I prefer to edit my photos in it and not in Lightroom:
   a. I start with denoising my image using Topaz Denoise 5. I generally start by selecting a preset which removes all the noise and then select preset which is by a step weaker and make adjustments to it. Sometimes I apply different denoising to different parts of the image.
   b. After that I add some clarity to the image using Topaz Clarity.
   c. Then I start to play with luminosity masks to improve contrast and colours of my photo. This is the most time consuming step of the whole process in my case. It might take just a few minutes but more often than not in takes hours... or even a few days.
   d. Finally I apply sharpening. Most of the time I sharpen my images with High-pass filter and I’m pretty satisfied with the results. As I often do have sky in my photos I often sharpen selectively. Sometimes I create Layer Mask and paint on it manually with a very soft brush. Often, however, I generate it automatically by finding edges in the image and applying sharpening only to them.
4. Finally I save my image as a JPEG with a maximum quality.
BLACK & WHITE HDR

Recently Black & White HDR photos are becoming quite popular. I also try to take some of them and on the next few pages you will find some samples:
There are two ways to achieve this effect:

- Desaturate a photo in Photomatix Pro by setting Saturation slider to 0 in case of Details Enhancer and to minimum value (-10) for other processing methods. In case of Details Enhancer you have to also make sure that both Saturation Highlights and Saturation Shadows are also set to 0.
- Converting the photo to grayscale in Photoshop or similar program.

It is possible to achieve striking results using any of these methods, however, I prefer to do this in post-production in Photoshop. Most of the time I use Topaz B&W Effects to convert my images to black&white.

After using this plugin from Topaz I usually increase contrast using Levels adjustments layer.
MULTIPLE TONE-MAPPING

After some time when one gets experienced in tone-mapping HDR photos it becomes clear that no matter what the settings are there are some scenes for which they simply don’t work - some areas look good with other settings, some look good with different ones, for instance:

- Eyes and cloth look better when using Details Enhancer but skin and hair look better when using Tone Compressor.
- Water sometimes looks better at different settings than sky.

There is a simple solution. The HDR photo has to be processed several times with different settings (eg. with eyes looking good and with cloths looking good). Then those photos can be blended in Photoshop (or even in Photomatix) using layer masks.

There are even photographers who blend this way photos from different HDR software. Others blend input photos with the tone-mapped one (I use it occasionally). So there are many options.
A long time ago when no one had heard about HDR, photographers were still able to increase the dynamic range of their photos. What they did, and many photographers still do, was to open several exposures in Photoshop and blend them using layer masks. When they blended the layers they had to decide which image to use for each region of the image. This way they could restore highlights using an underexposed photo and details in shadows using an overexposed one.

Although very old this technique got quite popular recently and nowadays is commonly referred to as manual blending or XDR for extended dynamic range (compared to high dynamic range).

Exposure Fusion is based on that experience but it is a more automatic process. Instead of doing it manually you can blend your images directly in Photomatix Pro. Basically exposure fusion is about taking the best pixels from all photos and outputting them to the final image. Whether a pixel can be considered good or bad depends on many factors like for instance colour saturation, well-exposedeness, low noise-level etc. Also exposure fusion isn’t limited to simple read and write operations. For any pixel it can take data from 1
image or from all images and to calculate the mean of values read (or some other characteristic). It can also increase colour saturation and much more. The possibilities are virtually endless.

Unfortunately not many HDR software offer exposure fusion. Photomatix (both Pro and Essentials) and Enfuse are the most popular ones with such functionality built-in. I will focus on the first one in this tutorial.

Before jumping into details on processing using Exposure Fusion, here are some of the benefits of using it:

- Exposure fusion might result in noise reduction (contrary to local tone-mapping which amplifies noise) – this makes it perfect for night and long-exposure “HDR” photos where noise might be a problem,
- Images have very natural look. Especially real-estate, night and foggy shots benefit from this natural look.
- Images are free of halo artifacts,
- Using exposure fusion might be easier because it has fewer parameters to set – also it is more intuitive as many photographers are already familiar with notion of blending images.

And here are drawbacks of it:

- Images lack local contrast compared to tone-mapped images. However, this can normally be improved in post-processing,
- High memory usage that increases with bit-depth and number of images.

As you can see from above, exposure fusion produces images that doesn’t have problems typical for HDR photography: noise, halos and unnatural look. Sounds great, doesn’t it? Well, that’s one of the reasons exposure fusion became so popular amongst real estate photographers. That’s also the reason why I use it for the majority of my night shots.
Creating fused images in Photomatix Pro doesn’t differ much from regular tone-mapping workflow. The main difference is step 1 below:

1. Make sure to use a dedicated RAW converter to convert images to JPG/TIFFs prior to loading them into Photomatix Pro. This way you will achieve best quality. The reason for this is that the Raw converter built into Photomatix is quite simple – although sufficient for tone-mapping it doesn’t produce as good results when used together with exposure fusion. For this reason I always develop my images in Lightroom and then export them to Photomatix using the Lightroom plug-in (which comes with your copy of Photomatix Pro).

2. You start by selecting photos to fuse in Lightroom. Right-click them and select Export -> Photomatix Pro.

3. Then you need to specify Preprocessing Options. I set them this way and clicked on the Export button:

   ![Settings for processing exported file](image)

   For this example I shot the photos with a tripod (7 exposures at 1 EV spacing). There could still be some small horizontal and vertical movement so I checked Align images checkbox. Also there were some people moving in the frame so I checked Show options to remove ghosts option (I will skip deghosting step this time though; if you need to read about it, go to ghosts removal section in this tutorial).

4. In Preview mode switch Process to Exposure Fusion this time:
5. Just below Process, there is a method combo-box. Select one of the following methods:
   - **Fusion/Natural** – it, and **Fusion/Real-Estate**, produces the most natural-looking results (hence the name). I will focus on this method in this tutorial,
   - **Fusion/Real-Estate** - this method works best for interior photos (real-estate like) but in my experience it works very well also for landscape photography if you want very natural looking images.
   - **Fusion/Intensive**,
   - **Fusion/Auto** – fuses images automatically, you can’t control the process at all,
   - **Fusion/Average** – averages the images. Same as above – you have no influence on the look of the images,
   - **Fusion/2 images** – let’s you select two images of all your exposures and then fuses only them,

6. Specify parameters. For **Fusion/Natural** they are:
- **Strength** – strength of local contrast enhancements. I usually leave it at 0.0 or move it to the left (negative values) as it tends to produce more natural looking images.

- **Brightness** - brightness of the fused image. Move the slider to the right to brighten your image and to the left to darken it.

- **Shadows Contrast** – brightens the shadows. I usually move this value to 10.0 which is maximum for this setting. This way I can restore more details in shadows.

- **Local contrast** – increases sharpness and local contrast of details in the image. I mentioned that Exposure Fusion does have worse local contrast than tone-mapping – this setting tries to overcome this. I try to keep this
value in range 0.0 to 3.0. Larger values might result in a painterly and unnatural look. Value of 2.0 usually works best.

- **White clip** – clips the highlights. I usually don’t change it.
- **Black clip** – clips the shadows. I usually don’t change it.
- **Midtone** - specifies brightness of midtones. I usually move it to the right to the degree that depends strictly on the image.
- **Color saturation** – increases or decreases saturation of colors in the image. I usually keep it at 0 as I play with colour later in Photoshop or Lightroom.

For my image I used settings from the image above.

7. Hit **Apply** button and save your image.
8. At this stage your photo might look like this:

It looks natural, that’s for sure. However, it lacks contrast and colours a little bit (especially compared to the tone-mapped images).

So what I typically do at this stage is to open my photos back in Lightroom or Photoshop and apply some adjustments there. Most of the time I increase contrast, colour saturation...
and sharpen my images. After that I end up with a photo like the one at the beginning of this section.
APPENDIX A: BATCH PROCESSING

Everything is fine and I hope clear up to now but how do you process HDR photos when you end up with a few hundreds to a few thousands of photos after a photo shoot?

Opening each of them in Photomatix Pro, making adjustments, saving and then applying final adjustments sounds like a tedious and very long task. Also it is rather difficult do choose the best image. When you have single images (i.e. not bracketed ones) you can compare them and choose one or few which you're going to process. But how to compare images when each of them is in fact built from 3, 5 or 7 photos? Should you compare underexposed images, normal exposure or maybe all images? This would complicate process of surveying very much. Yet another thing is doing HDR timelapse which would also require quite a lot of time to process.

Luckily, the solution to above problems is quite simple - use batch processing feature instead. Batch processing allows you to process similar images all at once using same settings for all of them. Photomatix Pro has this feature built-in and as you will see in a minute it's quite powerful.

CHOOSING AND PREPARING PHOTOS

As mentioned above, all photos in the batch will be processed with the same settings, so you first need to select photos for processing. Generally I try to choose photos which are very similar to each other, have similar tones and light. Most of the time I create new folder in Lightroom (or Windows Explorer) and move all selected photos to it.

Then I take one bracketed sequence from this folder and open it in Photomatix Pro, choose preset and make adjustments to it, then I save it as a new preset (with a name like Batch) which I will then use in batch processing. Why this is necessary? Batch processing doesn't allow you to preview your adjustments (this is same way as batch processing in Photoshop CS for instance) so you need what settings to use.

I then close Preview mode with X button (there is no need to process a photo).

BATCH GUI

Now open batch itself by selecting Automate -> Batch Processing from main menu (or use CTRL + B shortcut on Windows; CMD + B on Mac). Following window will appear. It might look quite complex at first but it isn't.
Elements of the GUI are described below:

1. This panel contains controls that allow you to select processing settings that will be used to tone-map and/or fuse images. You can either use preset (built-in or custom) by selecting it from the list if Preset radio button is selected or use custom settings (or multiple presets) by clicking on the Set button when Custom settings or multiple presets option is selected. After clicking on the set button you can select as many presets as you wish.

2. This is section that allows you to specify how the images will be pre-processed. Most of these settings correspond to the settings from the Merge to HDR Options window so I won't cover them here again.
   - Create intermediary 32-bit HDR file instructs Photomatix Pro to create and store 32-bit HDR file on disk so you can use it later to tone-map it in Photomatix or another program. Skip HDR processing instructs Photomatix to skip all of the processing apart from merging photos to HDRs.
   - More Preprocessing Options button opens another window that lets you specify additional settings like noise reduction strength, deghosting strength or white balance.
3. Below methods section there is a section allowing you to choose number of exposures each of the bracketed sequences has. If you used sequences with 3 bracketed shots choose 3. If 5, select 5. But what if you used sequences with both 3, 5 and 7 images? It's still possible. Click on the Advanced button and choose **Automatically detect number of bracketed frames** option.

4. Underneath there is a **Source** files section. If you want to process whole folder choose **Selection by folder** and then click on the **Select folder** button and navigate to your folder. If you, however, prefer to process only specific files, choose **Selection by individual files** and then click on the **Select files** button and in the opened window select files you want to process. There is also a list of files. Clicking on any file in it will show small preview of it to the right. There is also option to remove file from the list (**Remove file** button) and filter files by type (**Filter by** combo box). If you want to process photos in subfolders be sure to check **Process subfolders** checkbox as otherwise those photos won't be processed.

5. In the top right part of the form there are 3 buttons:
   - Run - starts the batch,
   - Close - close the batch window,
   - Stop - cancels the batch processing. Note that this button appears only after clicking on the Run button.

6. Below there is large text section - it's a batch log. Generally speaking all messages will appear here. Most of them will be various pieces of information to let you know what's going on but also errors will appear here. Errors might appear when Photomatix could not process images for some reason (eg. when it couldn't find bracketed sequences).

7. In the bottom right corner you have settings to specify your output settings. First you have to specify output directory and you have two options here:
   - **Created in Source Folder** - this is default option. Photomatix Pro will create new folder in your source directory and save the output images there. The folder will have name in form PhotomatixResultsXX where XX is a number. For instance if there is already PhotomatixResults01, Photomatix will save result files under PhotomatixResults02.
   - **Customized location** - choose this option when you want to save your images to destination of your choice.

Then you can select format of the saved image (JPEG, 8- and 16-bit TIFF files) and in case of JPEGs specify image quality (in the range 0 to 100).

Moreover, you can select format of 32-bit HDR image generating when **Create intermediary 32-bit HDR files** option is checked. You can select radiance (HDR) and EXR formats.

In this section there is also a **Naming & Output Options** button. Clicking it brings another window:
In the Naming section you can select naming scheme and append custom suffix to the output files (eg. I use "_HDR" suffix).

Resizing section allows you to choose output size of the images. By checking Resize output to checkbox and typing width and height you can shrink the output images (please note you cannot use it to enlarge your photos).

Finishing section in turn allows you to apply finishing touch to all output images. You can apply contrast and sharpening enhancements.
RUNNING BATCH

This is very simple, just:

1. Set settings as desired
2. Click Run button
3. Wait (or eat a dinner or in case you have thousands of shots to process - go for a walk). It's slow process

APPENDIX B: PHOTOMATIX PRO GUI TIPS & TRICKS

Regarding tone mapping or fusion settings:

- Double clicking on the setting slider resets it to its defaults.
- You can click on a value next to the slider to edit it by typing it - useful when you know exactly what to put there.
- Using mouse wheel on the settings window will scroll it horizontally.
- With CTRL key pressed when mouse pointer is over a slider you can use mouse wheel to control the value. It’s very useful if you want to move it just slightly as this method permits for very small value changes (like 1 or 2 increments - what I mean is it's very precise).
- Using mouse wheel on the presets window will scroll it (horizontally or vertically depending on its orientation).
- When a preset is selected (marked by a white border in the presets window) you can move to the previous preset by using Up or Left arrow keys. To move to the next one you can use Down or Right arrow keys. This way you can quickly go through available presets to compare the results.

Regarding image (all types of previews and final image):

- Using mouse wheel on the image will scroll it horizontally (when horizontal scrollbar is visible). You can also use mouse wheel on the image scrollbars to scroll horizontally or vertically.
- Using mouse wheel on the image while CTRL key is pressed will zoom it

Other:

- You can also use a number of shortcuts like CTRL+O to open file or CTRL+L to load bracketed set - make sure to study menu items (as shortcuts are listed right to them).
- You can set orientation of the presets window in preferences. Just open Preferences - General Tab -> Orientation of Preset Thumbnails. I always have it in vertical orientation.

APPENDIX C: DEALING WITH HALO ARTIFACTS
Halo artifacts. One of the nightmares in HDR photography. They appear between regions of different luminosity and virtually ruin any photo. You might have great composition, light and colours but if you have halos in your photo - it won't be considered good - rather poorly executed.

It might be that even when you followed all my steps above and used low settings for Strength there are still some ugly halo artifacts. They can appear especially in the sunrise/sunset scenes and after using some Photoshop filters (like eg. Topaz or even Curves adjustments layer).

What you will need is Photoshop. First open your image with halo artifacts:

At full size it doesn't look very bad but hit CTRL + MINUS keys several times to see nasty halo artifacts. Ugh...

As you see highlights in the sky are a way too strong and also shadows are a way too deep. So the easiest thing to do would be to adjust both by using Curves adjustments layer.

First make sure to select sky only (eg. with Wand selection tool) as the halos are present only in it. Then add Curves adjustment layer.
For this image I used following settings:

Note I darkened highlights and brightened shadows a little bit. After that adjustment the image looks like this:

It's slightly better but still far from good.
So what we will do is to manually Dodge & Burn the sky to get rid of too dark regions and too bright ones too. Fear not - this tool is very easy to do (and powerful too!) but I admit one has to get used to using it.

You can use Dodge and Burn tools from the Photoshop toolbox for this but they have one serious disadvantage - they both are destructive tools. I prefer editing my images in a non-destructive way so I do the following:

1. Press CTRL + SHIFT + N (CMD + SHIFT + N on Mac) to create a new layer. In a dialog box that appears, change Mode to Soft Light and also check the box at the bottom to fill the new layer with neutral grey colour.
2. Press Ok, to create the layer.
3. With your new layer selected select Brush tool and change its Flow to around 2 - 3%. Also make sure your brush is soft.
4. Paint over dark regions with White colour and over bright ones with Black. Using White colour has effect of brightening the image, while using Black - of darkening it. So when you use White on Shadows you brighten them up. Similarly when you use Black on Highlights you darken them.
5. While painting make sure to zoom out from time to time because it might be easier to see halos at smaller magnification.

Here is the final result:
Although still not perfect, it now does look a lot better :) 

For your reference, here is also the Dodge & Burn layer I used. Note that the brightest parts of the image were painted with black and darkest with white colour.
APPENDIX D: QUICK HDR TIPS

1. Make sure that brightest photo of your bracketed sequence has shadows in midtones to avoid enhancing noise in the final tone-mapped image.
2. When there are very bright light sources in the image (like lamps for instance) make sure to clip the whites a little bit - otherwise you will lose effect of glowing.
3. When creating HDR panoramas, it's better to merge same exposures to panoramas first (eg. 0 EV exposures to one panorama; +2 EV to another) and then merge them to HDR and tone-map/fuse. It will help you avoid some artificats.
4. One of the best things I learnt about HDR and tone-mapping in the recent years is that it's the beginning of the process of developing a photo, not the final step. Many people would like to throw their photo into Photomatix, process it and share on the net. However, making a good HDR photo requires much more work.