**Technical Note**

# Comparing Nearly Identical Images Using "Beyond Compare"

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**Abstract**: A recent article outlined methods for the comparison of nearly identical images. These included a byte-by-byte comparison using specialized software as well as a visual comparison by highlighting differences in pixels between the two images based on a threshold using Photoshop. This article presents an example of image comparison and proposes another, simpler solution, using software named Beyond Compare, that may be of interest to investigators.

## Introduction

A recent article [1] on video frame comparison presented methods to compare nearly identical images using the X-Ways Forensics software for byte-by-byte comparison and Adobe Photoshop (Adobe Systems Inc., San Jose, CA) for visual comparison. The goal was to identify nonmatching pixels that could be used to determine whether one of the images had been edited or to highlight irregularities of recording devices. The Photoshop method involved using layers and filters to overlay the two images, highlighting any differences in pixels within a given threshold. Although this method works, it involves many steps and can be very time consuming if an investigator is dealing with a large number of images. Beyond Compare (Scooter Software, Inc., Madison, WI) offers a simpler way to compare images—both byte by byte and visually—and provides several additional options that may be useful to an investigator.

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Beyond Compare was first released in 1996. It provides side-by-side comparison for all sorts of different file formats, such as text files, arbitrary binary files, and image files, and also provides methods for easily merging text documents. As of version 3, Beyond Compare includes a built-in visual image comparison tool that is extremely simple to use and very effective. If it is found to be suitable for an investigator's work, it can save a lot of time whenever a comparison of nearly identical images is required.

## Methods

### *Example*

To demonstrate some of the capabilities and advantages of Beyond Compare, an example of a slightly modified image was created. The original image (Figure 1) was opened in Photoshop. The dodge tool and the spot healing brush tool were used to modify it in two places, and a copy was saved in the same format. The resulting image is different at the pixel level, but visually, it is virtually indistinguishable from the original (Figure 2). These two images were compared visually using the Photoshop methods and then using Beyond Compare, and finally compared byte by byte using Beyond Compare's hexadecimal comparison tool.

### *Photoshop Method*

The two images (original and modified) were compared using Photoshop CS2 according to the methods laid out by Koenig et al. [1] At three different points in the process they outline, it is possible to examine results visually: after applying the "difference" blending mode (steps 4–6), using the "levels" adjustment (step 7b), and using the "threshold" adjustment (step 7c).

After applying the "difference" blending mode (Figure 3), it is possible to discern only one of the two differences in the images (Figure 4). This is the area that was modified using the spot healing brush tool to remove a berry from the tree in the original image.

After applying the "levels" adjustment technique, it is now possible to discern both differences in the image (Figure 5). The modification to the tree in the upper right is still visible. Additionally, the areas where the dodge tool was used to lighten the window frame are now visible.

Using the "threshold" adjustment technique, the results are virtually the same as the "levels" adjustment, and both changes are visible (Figure 6). In this mode, black indicates no change to the pixels within the threshold and white pixels indicate a modification. Adjusting the threshold level changes which pixels are shown as having been modified.

Each of these techniques requires some experience with Photoshop because they involve working with layers, selections, and filters. They can also be time consuming (especially if the investigator has a number of images to examine), and, because there are multiple steps involved, it is easy to make mistakes. Note that by using Photoshop's ability to record and playback actions, some of this workflow can be automated, which may help save time and minimize error.

Another disadvantage to using the Photoshop techniques, though, is simple usability. Although it is possible for the user to keep the two images (original and modified) open and to perform adjustments in a third window, it is much more convenient to have them side by side, maintaining the same scale and location as the user zooms in and out and moves around the images, as we will see with Beyond Compare.

*Beyond Compare Method*

To compare the two images (original and modified) using Beyond Compare version 3, the files were selected in Windows Explorer, the context menu was brought up by right-clicking the mouse, and Beyond Compare's "compare" option was selected (Figure 7). If there are several images to compare, it is possible to compare two folders of files as well. Beyond Compare will display the two folders and their contents side by side, allowing the user to click any pair of files to compare.

When comparing two images visually, Beyond Compare displays a window with three panes: the first image, the comparison, and the second image (Figure 8). The layout of the panes may be changed in the tool bar, however, the default layout (tolerance mode) works very well with a widescreen monitor. Zooming in on any of the images zooms the other two panes simultaneously so the images always maintain the same scale. Likewise, scrolling any of the images will affect the other two panes. This makes it extremely easy to zoom in on a difference and see the original and the modified all at once (Figure 9). When the mouse moves over any of the images, the text at the bottom of each pane shows the x-y location in the image of the pixel under the mouse, as well as the pixel's RGB (red, green, blue) values.

*Figure 1*
*Original image.*

*Figure 2*
*Modified image.*

*Figure 3*
*After blending using the "difference" mode.*

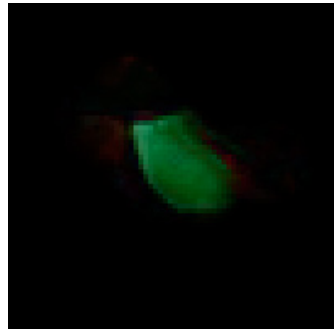

*Figure 4*
*Zoomed in 300% on the only visible difference.*

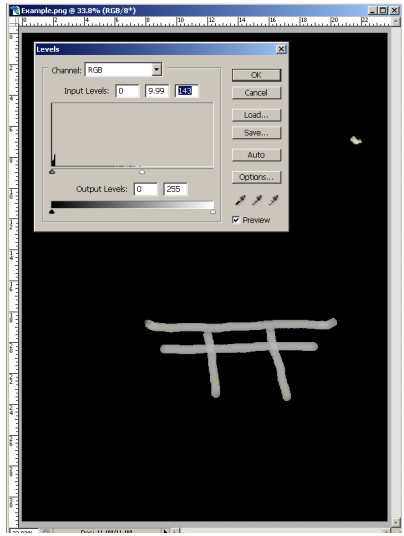


*Figure 5*
*Using Photoshop's "levels" adjustment.*

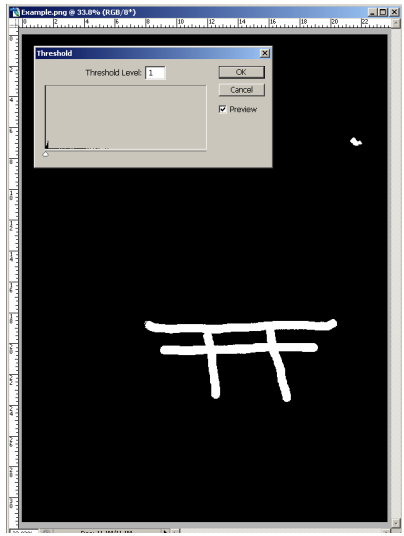


*Figure 6*
*Using Photoshop's "threshold" adjustment.*

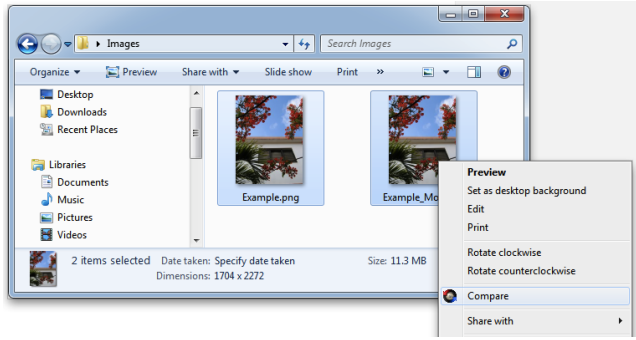


*Figure 7*

*Comparing two images with Beyond Compare's context menu.*

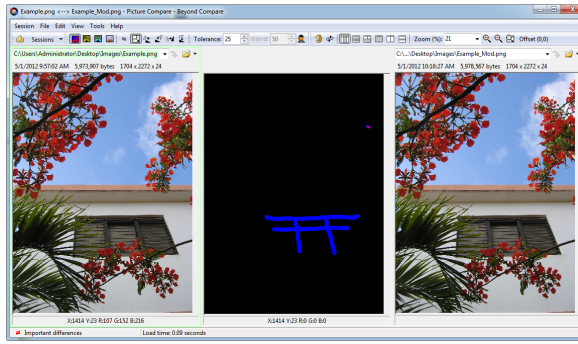

*Figure 8*

*Initial comparison.*

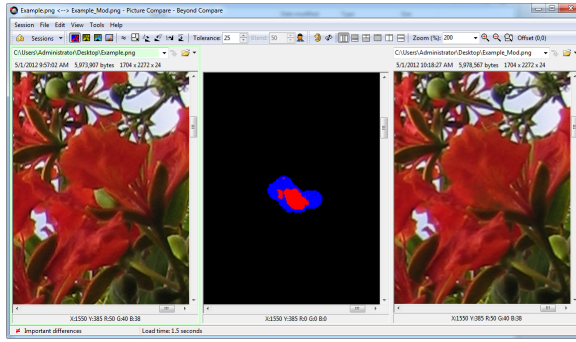

*Figure 9*

*Initial comparison zoomed in on a difference.*

Beyond Compare offers four different image comparison modes: tolerance mode, mismatch range mode, binary operation mode, and blend mode. The most interesting one for our purposes is tolerance mode. This mode presents the two images along with the resulting differences highlighted in user-selected colors for pixels that are the same, different, or similar. The blue pixels in the comparison (Figure 8) show where Photoshop's dodge tool was used to lighten the image around the window frame. The red and blue spot in the upper right is where the spot healing tool was used to remove a green berry from the tree.

Beyond Compare uses the concept of similarity of pixels, so it is not limited to showing absolute differences. The degree of similarity of pixels before they are considered *different* may be adjusted by changing the tolerance level in the tool bar.

The colors used to indicate *same*, *different*, and *similar* pixels may be changed in the application's preferences. The examples presented here use the default colors, which are black, red, and blue for same, different, and similar, respectively (Figure 10).

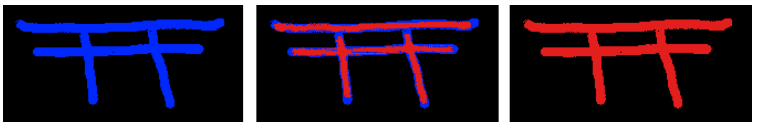

*Figure 10*
*Tolerance set to 25 (default), 3, and 0.*

The image comparison mode may be changed in the tool bar above the images. The second mode that may be useful for an investigator is the mismatch range mode. In this mode, pixels that are different are shown using only one color (the default is yellow), and the intensity of the pixel indicates the relative difference (Figure 11), so the brighter the pixel, the larger the difference.

Binary mode shows the absolute difference of the pixels of two images by applying one of three binary operations: XOR, AND, or OR. This binary operation is applied to each pixel location in the images, resulting in the comparison image (Figure 12). It is unclear to the author whether this mode provides any advantage over the previous two modes for the purposes of an investigation.

The final mode–blend mode–is used to combine two images and is therefore not suitable for the comparison of similar images.

In the example, both the original and modified images were the same file format–PNG (Portable Network Graphics). Beyond Compare, however, allows comparison of images saved in different file formats. So, for example, if one has images that look the same, but one is a PNG and the other is a JPEG (Joint Photographic Experts Group), they can still be compared to each other (Figure 13).

As explained earlier, the blue pixels in the difference image represent *similar* pixels within the given tolerance. Each image format stores color information differently, so the images may have slightly different RGB values. These will show up in the difference image as *similar* pixels. Beyond Compare provides a button in the tool bar—ignore unimportant differences—to hide pixels that are only similar, highlighting any larger differences. So in the example from Figure 13, clicking this button would result in the difference image only showing the red differences.

Another useful feature is the ability to compare two images that are different dimensions. If an investigator has a cropped section to compare against a larger image, they may still be compared using Beyond Compare. Figure 14 shows a comparison of a cropped portion of the modified image against the original.

Should a byte-by-byte comparison of two images be required, Beyond Compare provides an easy way to view these differences, too. The default action when selecting images for comparison using Windows Explorer is to show the visual comparison tool. Once the images are compared in this manner, selecting Session > Compare Files Using > Hex Compare will open a new tab that displays the image differences at the byte level (Figure 15).

This view displays the hexadecimal values of each image side by side and highlights any difference between the two. This may be useful if the investigator needs to record actual byte differences.

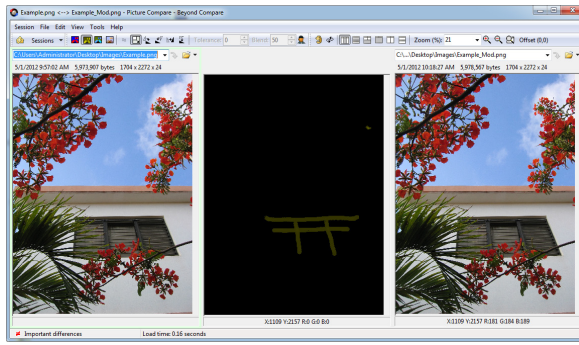

*Figure 11*

*Mismatch range mode.*

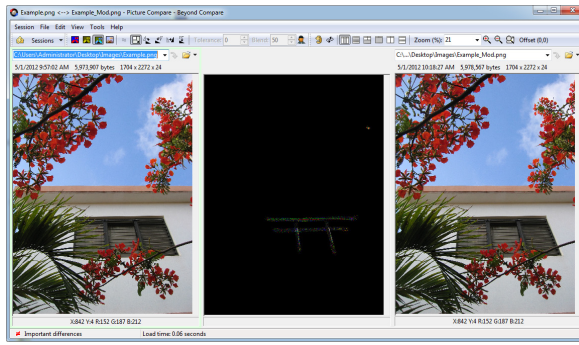

*Figure 12*

*Binary mode.*

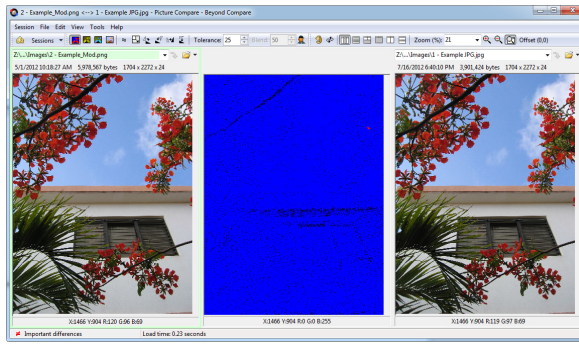

*Figure 13*

*Comparing a PNG to a JPEG.*

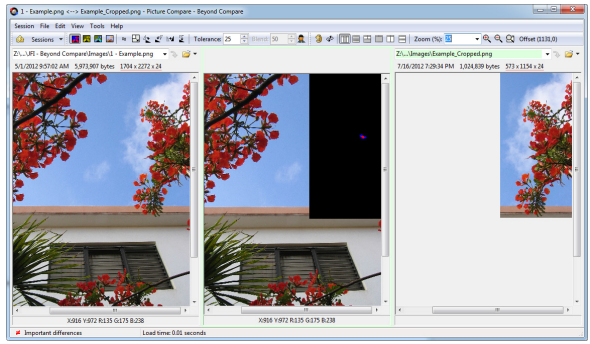

*Figure 14*

*Comparing a cropped portion of an image.*

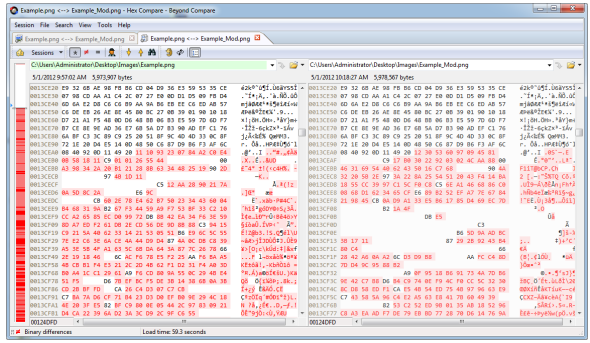

*Figure 15*

*Hexadecimal comparison.*

## Conclusion

Photoshop is extremely powerful software and, because it is such a general tool, users have created workflows to perform all sorts of tasks. Sometimes, however, there are more efficient, user-friendly ways to accomplish these tasks. This article proposes that image comparison is one such task. It is certainly possible to accomplish in Photoshop, as outlined in the article which inspired this one, but other tools exist–such as Beyond Compare–that are worthy of investigation.

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## References

1. Koenig, B. E.; Lacey D. S.; Richards G. B. Video Frame Comparisons in Digital Video Authenticity Analyses. *J. For. Ident*. **2012**, *62* (2), 174–176.