



Corrected with lens shift



Corrected with computer

PERSPECTIVE CONTROL WITH LENS SHIFT OR WITH YOUR COMPUTER?

CORRECT PRECEDURE AND A COMPARISON OF QUALITY

Digital images suffering from converging verticals ("keystone distortion") or other perspective defects can be corrected post-taking with the Photoshop® software. This could lead to the assumption that professional adjustable cameras and lenses with a large image circle and therefore capable of parallel lens shift are not necessary any more. This article proves that perspective control with lens shift is not only the easier and faster but also the more precise procedure ensuring correct proportions and visible better image quality.

Digital photography changed quite something, made a lot of things easier and image editing software opened up new possibilities nobody ever dreamed of before. One of these possibilities is the distortion correction of converging vertical lines (keystone distortion) with an up or down shifted camera. Especially for product, industrial and building photography with wide-angle lenses, these converging lines are an irritating element. In analog photography adjustable cameras, mostly large format cameras with a sheet film or roll film back, were used for taking this kind of images. The vertical position of the focusing screen or the image plane of these adjusted cameras generates parallelism to the front or the vertical edges of a building or to any other object.

Therefore it allows a full distortion correction of converging vertical lines and at the same time a maintenance of the exact proportions (width-height ratio), even in an oblique upward or downward taking direction. Depending on the purpose of the images, a remaining perspective of 25%, resulting from an incomplete vertical alignment, which leaves a 25% image plane declination, could achieve a more aesthetic effect: The converging lines are now reduced to a level where they are no longer irritating. But they are still present in a sufficient extent for giving a perspective correct impression to the viewer. With the triumph of digital technology, also in professional photography, not only the image formats (from sheet film, over roll film, to 35 mm formats) got smaller, but also an apparently perfect technique of perspec-

tive manipulation has been created due to increasingly powerful image processing software. Consequently, some photographers believed wrongly that nowadays professional adjustable cameras would not be necessary any more. However, this article will prove that they are still indispensable for producing high-quality images.

IS CORRECT PERSPECTIVE CONTROL POSSIBLE WITH THE COMPUTER?

Adobe Photoshop® is the most common image editing software for digital and digitalized images. In the "Edit" menu of this software you find "Transform", which contains the function "Perspective". When the whole area of an image has been defined as "selected" before, with this function a trapezoidal transformation can be effected

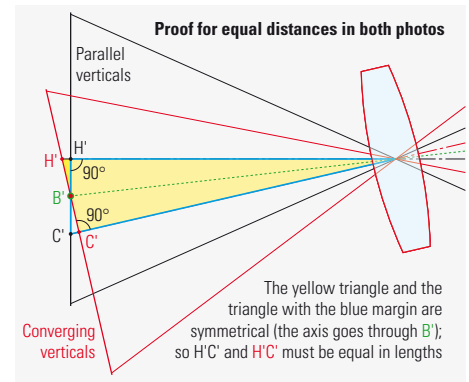
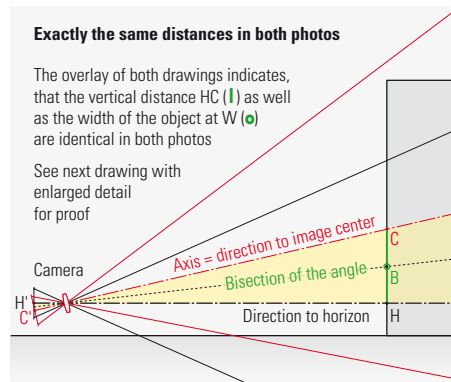
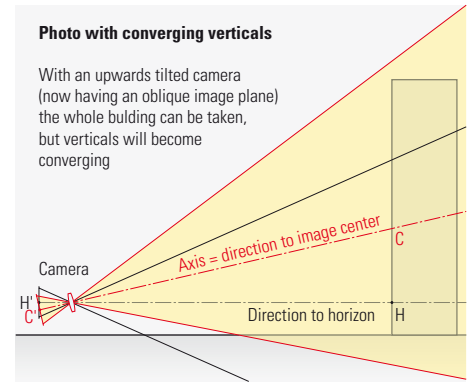
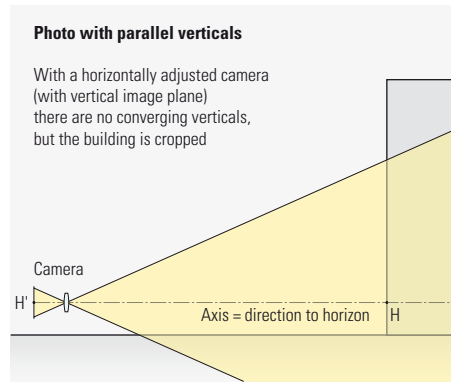
on images by dragging horizontally its corner handles (which appear on the dashed frame of the transformation box after clicking "Perspective"). The first two pictures below show how the converging verticals on the church picture can be adjusted in a parallel vertical direction by compressing one image border (in this case the lower one) or by extending the opposite one (in this case the upper one).

What appears to be an easy and valid solution of the problem on first sight, unfortunately reveals a number of intolerable defects: the parallelism has been achieved at the expense of the correctness of the proportions! The first picture is too narrow compared to its height, the second one is too broad. There might be images where you don't notice these falsified proportions, but they are unacceptable in architectural, furniture or other kinds of product photography and even in landscape photography, where mountains in the background could appear flatter or steeper.

HOW TO PRECEED FOR SAVING THE CORRECT PROPORTIONS

Let's compare the first picture on the previous page, taken with a tilted camera, with the second one, taken with an adjustable camera with a vertically aligned back (image plane) and an upward parallel lens shift. The following effect can be noticed: The arches on the image with the correctly rectified perspective are increasingly extended in the upper half of the picture, while everything in the lower half gets increasingly compressed. This means that proportions change depending on their position and that is exactly, what makes the whole thing so complicated. Please take a look now at the four drawings on this page. On the fourth one you will find one vertical and one horizontal distance on the undistorted picture (vertical image plan in black), which remain equal in lengths in spite of the compressions and extensions, on the distorted picture (oblique image plain in red):

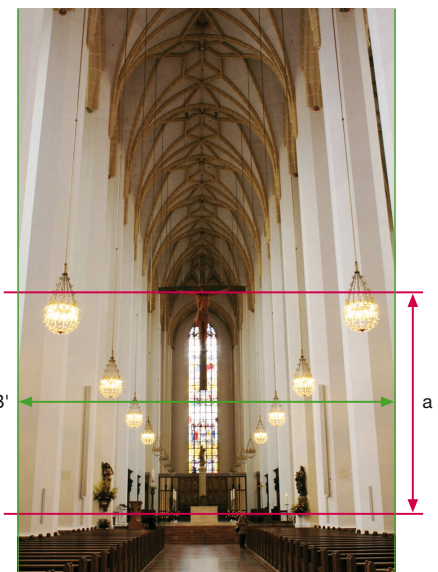
1. The vertical distance H'C' between the

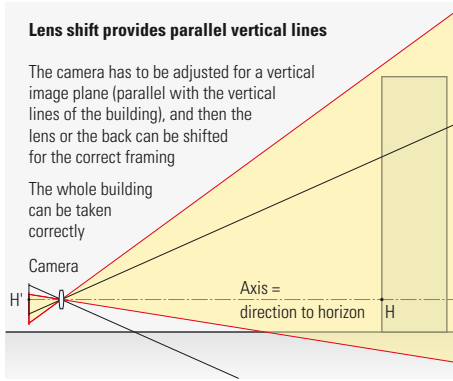


horizontal line H' and the image center C' is of identical lengths in both pictures.
 2. Because of the vertical and the tilted image plane intersecting in the horizontal line B' (appearing only as a point in this drawing) on the bisection of the angle between the direction to the horizon and the direction to the image center, all objects there have to be equal in width on both images. Using the trapezoidal distortion of the Photoshop® command "Edit" > "Transform" > "Perspective", the proportions should be correct, if we follow these steps: Make sure that the image maintains a constant width at B' by dragging the upper corner handle outside and the lower one inside. Then stretch the image vertically, so that the distance between the horizon line H' and the line through the original image center C' becomes again identical to that in the image with the converging lines.

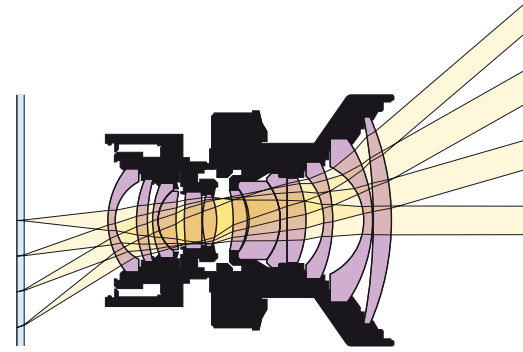
STEP-BY-STEP INSTRUCTION FOR CORRECT PERSPECTIVE CONTROL

Let's take as an example the picture with the converging lines shown below. For the view on your monitor with Photoshop® choose the maximal reproduction size (Macintosh: shortcut [⌘] + [0]). Use the Zoom Out tool with the minus sign for reducing the image (Macintosh: mouse click at shortcut [Alt] + [⌘] + [space bar] and for creating a gray surrounding area. After this select the whole image area (Macintosh: shortcut [⌘] + [A]). By drawing vertical and horizontal auxiliary lines on every image border, the auxiliary lines snap exactly in the borders of the image area. Then draw two horizontal auxiliary lines C' and H': the first one to the image center (snaps in automatically too, when dragged slowly over the image center) and the second one at





The Rodenstock Apo-Sironar digital HR 28 mm 1:4.5 allows photos of high buildings without converging lines even at very short distances. Furthermore, the short focal length provides product photos with enhanced perspective in the studio.



Very oblique light rays cause dark corners on sensors with micro lenses. This is not an issue with the retro focus design of the Rodenstock Apo-Sironar digital HR 35 mm 1:4.

the level of the horizon line H', or in other words at "eye-level" with the camera (two red lines in the distorted photo below the text column to the left). Finally, place another horizontal line B' halfway between them (green line with arrowheads), at the place where the bisection of the angle cuts the picture (according to the drawing on the left page). Strictly speaking, line B' should be a little above (around 1% to 3%) the middle between the centerline and the horizon. But as this imprecision is hardly visible in the final rectified picture, it is alright taking the exact middle.

As the picture gets wider and higher during the following steps, we need a larger canvas size. Click "Canvas Size" at the "Image" menu, and when the corresponding input mask has appeared, widen the canvas size symmetrically on both sides about 30% to 60% by entering a larger width. Using the same input mask, extend it only upwards about 20% to 70% (in each case: the more oblique the converging verticals, the more the canvas size has to be enlarged). After this, the picture is surrounded by a blank area on both sides and on the top.

Now only the image area (not the whole canvas size!) has to be highlighted again as a rectangular "Selection", because extending the canvas size automatically cancels the previous selection. The auxiliary lines drawn before on all four sides, make sure that the selected rectangle runs exactly alongside the image borders.

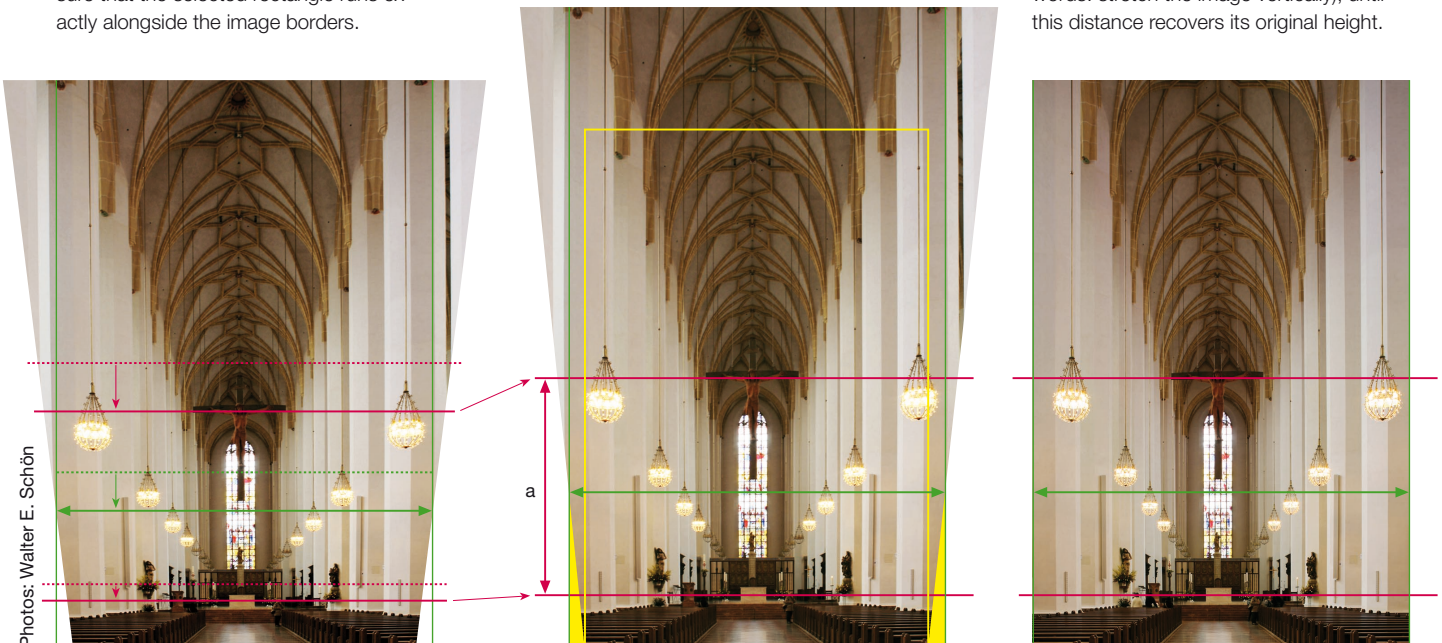
After activating the selection like this, open the "Edit" menu, go to the "Transform" submenu and click "Perspective". As a result, a handle appears on each corner and in the center of each dotted line of the selected rectangle.

Before starting perspective control, two prominent image details have to be kept in mind: The first one lies on the horizontal centerline C' (red colored in the images below), here for example the bottom edge of the crossbar. The second one lies on the bisection of the angle B' (green colored), here for example the lower edge of a red square near the center of the window. Later these details have to be found again, once they shifted downwards as a result of the perspective control.

By pulling outwards the handle on one of the upper corners along its horizontal auxiliary line, the picture undergoes a trapezoidal deformation. In doing so, the converging verticals get more and more parallel. But a complete parallelisation of the converging verticals is unwanted, because the image would get too broad. Therefore leave slight converging verticals and then pull inwards the handle on one of the lower corners along its horizontal auxiliary line. So the image, which got too broad before, returns a little more narrow. Now control if the image maintained its original width on the detail kept in mind at the (green) bisection of the angle (lower edge of a red

square near the center of the window), which shifted downwards putting perspective control (as seen on the left of the three pictures below). This can be made out by comparing with the vertical auxiliary lines. If the picture have not got the correct width at this detail yet, it can be adjusted by moving carefully the handles horizontally. In this iterative way the converging lines can be parallelised while maintaining the image width at the down-shifted bisection of the angle B'. But also the image details located on the previous centerline (bottom edge of the crossbar) and on the horizon line (eye level of the person in the central corridor) shifted down differently. Unfortunately the auxiliary lines drawn there remained at their original level (dashed lines on the picture down to the left).

The converging verticals have been parallelised and the image width at the bisection of the angle has been maintained. Now it remains to ensure that also the distance a, which was shortened using perspective control, regains its original height. The distance a is the distance between the picture details situated before on the (red) horizontal lines through the previous image center and on the horizon level. Therefore go to the "Edit" menu, choose "Transform" and click at "Distort". Pull a vertical auxiliary line onto the handle in the center of the top edge (it snaps in). Then pull this handle upwards along the auxiliary line (in other words: stretch the image vertically), until this distance recovers its original height.



Photos: Walter E. Schön

The central image on the previous page shows the result of our perspective control including the correct proportions (width to height). Let's compare this picture with the one next to it, which was perfectly distortion corrected by a parallel lens shift of the adjustable camera. Concerning both the elimination of the converging verticals and the restoration of the correct proportions, the result, which has been achieved with Photoshop®, does not differ from that achieved with the adjustable camera.

THE BIG DRAWBACK OF PERSPECTIVE CONTROL WITH THE COMPUTER

I wrote "concerning" this matter intentionally, to point out that regarding other aspects, perspective control with the computer has led to serious deterioration: The necessary trapezoidal distortion and vertical stretching cause a complex recalculation (interpolation) of the pixels. Especially in the upper part of the picture an upwardly **increasing blur** results from this interpolation because of the following: In a first step the image area has been expanded, spreading out the pixels. Then the interpolation calculates new pixels to fill in the regular pixel grid (with the result of losing image structures, instead of gaining them). In the end a large part of the image area was cut off, **losing millions of pixels** of the original picture! Because of the too small images on the previous page, this effect cannot be seen clearly. So for a better

view you find another image example below. Its resolution has been reduced before applying perspective control to an extent, that the loss of resolution in the final result can be seen clearly, in spite of the still quite small image format. As in the last two image examples on the previous page, also here a **further loss of image area**, and therefore a further loss of resolution, can be noticed. This occurs because the image format gets smaller at the bottom due to the missing (yellow) triangles down on the left and right. An image taken with parallel lens shift of the adjustable camera would show the larger green-framed image area. For the final apply of this image, where the width-to-height ratio (e.g. the print page) has to be kept unchanged, a further crop of the usable area to the yellow frame below, is necessary. Consequently even more precious pixels get lost! In the images on the previous page taken with a focal length of 35 mm, this loss was about nearly 30%. In the images below taken with a shorter focal lengths of 28 mm and a more angled camera, the loss is about even more than 44% (relating to the original image, not the one with perspective control). This is shown in the left image by the yellow trapezoidal area, which becomes the usable area after the application of perspective control. Considering a sensor resolution of 22 megapixels, only 12.3 of these megapixels would be left. Whereas the sharpness on the bottom would correspond to



Digital lenses with oversized image circles for parallel shifts with professional adjustable cameras are essential for taking photos with correctly rectified perspective.

the sharpness of 20 megapixels and the sharpness on the top to that of not even 10 megapixels. Finally, also the enormous expenditure of time necessary for adopting perspective control with the computer cannot be ignored: What takes less than half a minute using distortion correction with the camera, occupies more than 15 minutes when doing it with the computer – obtaining unfortunately a worse image sharpness. We recommend every photographer using this precise perspective control technique described here, only as a stopgap, in case a professional adjustable camera with a high-quality digital lens providing shift capability is not available. *Walter E. Schön*

Reduction in quality by perspective control with the computer

For demonstrating the decline in quality using perspective control with the computer, this image has been recalculated to a resolution of 435x644 pixels. So the pixel structure can be visualized in spite of the small reproduction size. Supposing an original of 22 megapixels, its sharpness corresponds to the sharpness of a print in the size of 41x62 cm (approx. DIN A2). The horizon line lies almost at the bottom image border, due to the highly tilted camera. The focal length of 28 mm was even shorter than used for the previous images. Perspective control with Photoshop® has been carried out according to the steps described on the previous pages:

1. Draw horizontal lines at the level of the horizon (red), through the image center (red) and half-way between these two lines as the bisection of the angle (green). Keep in mind prominent image details (circles).
2. Mark the image width with vertical auxiliary lines on the left and right border (here only indicated by short green lines).
3. Correct converging lines with "Transform" > "Perspective", so that the image width remains identical in the height of the detail on the bisection of the angle (center of the triangular window top). By doing so this detail will shift a little downwards.
4. Stretch the image upwards by using the "Distort" function, so that the details on the centerline and on the horizon line (red),

have the identical distance to each other as before. In the upper part of the image, which has been enormously enlarged because of the steep camera angle, the resulting lack of sharpness can be clearly seen. The rectangular image (yellow frame) usable in a width-to-height ratio of 2:3, is clearly smaller than it would be using perspective control with a camera, because of the lack of the two yellow triangles down on the left and right.

