

# A low-cost technique for single-row panoramas

Dr John Miller

Wooler, Northumberland NE71 6EL

February 2023

## 1. Why panoramas?

Digital image files are just a bunch of numbers. With numbers you can do arithmetic. With arithmetic, and a computer to help, you can do lots of tricks with digital images. Among these tricks are altering an image (a.k.a. *image editing*); increasing image depth of field (a.k.a. *focus stacking*); increasing the range of image brightness (a.k.a. *High Dynamic Range*); or joining two or more images together (a.k.a. *stitched panoramas*). What follows is about the last trick.

Making a single-row<sup>1</sup> stitched panorama is simple. Rotating the camera sideways between exposures will produce images which overlap. Matching features in the overlap areas allow stitching software to fuse the images into a single composite image, the stitched panorama. Typically the overlap is about one-third of the width of an image.

Moderately-priced digital cameras have sensors with about 20 million pixels (20 MPx). Two side-by-side 20 MPx images give a 33 MPx panorama, three images a 46 MPx panorama and four images a 60 MPx panorama. In other words, a stitched panorama can do better than a medium-format single image, at a fraction of the cost. Not only that, a wide-angle stitched panorama can be made with the more attractive perspective of a telephoto lens.

As always there is a down-side. If the subject moves, it shows in the panorama, because of the time gap between exposures.

## 2. Camera mount

See Figure 1. The camera mount supports the camera during image exposures. It has three parts (*none specialised for panoramas*):

1. a monopod support (about £20 for a basic monopod);
2. an Arca-Swiss clamp (about £15), screwed onto the monopod;
3. an L-bracket, to allow easy swapping between landscape and portrait orientation of the camera (about £15).

The monopod is unmodified. The Arca-Swiss clamp has a 32mm diameter bullseye spirit level substituted for the original 10mm diameter level. The L-bracket has a penny washer bonded to it, to provide a good seating for clamping a camera to the L-bracket. These modifications are helpful rather than essential.

## 3. Some technicalities

Multi-image panoramas are produced by rotating the camera stepwise between exposures. Movements left-and-right are rotations around a vertical axis, and movements up-and-down are rotations around a horizontal axis.

Ideally, the overlap areas of adjoining exposed images should coincide exactly. Coincidence occurs when the camera rotates about vertical and horizontal axes, both passing through the entrance pupil of the camera lens.

The entrance pupil is the lens aperture seen from the front of the lens (i.e. where the light goes in). If the entrance pupil does not coincide with an axis of rotation, the entrance pupil position is not stationary but moves along an arc. As successive exposures then are from different positions, in successive images foreground objects change position relative to the distant background. This shows itself in discontinuities in lines and edges that cross the joins in the panorama between one image and its neighbours.

## 4. Choice of camera

In single-row stitched panoramas, the axis of rotation should be vertical. The camera mount described in §2 has no adjustment along the optical axis of the camera's lens. For the mount to work well, a digital camera with a small sensor is unavoidable. A small sensor provides the least distance from the vertical axis to the (unknown) position of the lens entrance pupil.

Ideally, all source images for the panorama should be shot identically. For this, the camera should have a manual (M) exposure mode, and be capable of manual focussing.

Among many others, candidate cameras are the Sony HX350 (20 MPx, 50x zoom, JPG output) and the Fujifilm HS30EXR (16 MPx, 30x zoom, JPG and raw output). Both are bridge cameras I own.

## 5. Making the exposures

With the camera mounted, the monopod is held vertical by centring the bubble in the bullseye spirit level. By keeping the bubble centred during repositioning, the mount rotates around a vertical axis. The principal function of the monopod is to facilitate camera rotation. Support against camera shake, though invaluable, is to some extent secondary.

See Figure 2 overleaf, which shows my Sony HX350 camera installed on the mount.



Figure 1: Camera mount

1 With more elaborate mount hardware, panoramas with two or more rows of side-by-side images can be made.

The camera's monitor screen on the back of the camera is set up to display a "Rule of thirds" grid, superimposed on the current image.

Moving between exposures uses the "Rule of thirds" grid to produce a one-third overlap. Only the vertical lines are needed. Assume for explanation left-to-right movement. Right-to-left movement is similar.

Start by displaying the first (left-most) image. On that image, identify on the image a feature lying on the right-most grid vertical. For the second exposure, rotate the camera (keeping the bubble centred) so that the left side of the screen coincides with the feature in the first exposure. The result is a one-third width overlap between the images.

For a third exposure, the second exposure becomes the new starting exposure. Further exposures repeat the procedure.

It is not easy to rotate by two-thirds of the image width and at the same time keep the spirit level centred. Doing so is a learnt skill that improves with practice. To make a good panorama, keeping the spirit level centred is more important than rotating exactly one-third of image width. A one-third overlap is generous as it helps the stitching software to reduce mismatches when it fuses the images.

Figure 2 shows the camera in portrait orientation, which provides maximum panorama height. Landscape orientation works equally well but for a given panorama width gives a smaller panorama area.



**Figure 2: Exposure procedure**

## 6. Software

The image files have to be stitched together to form the panorama. After stitching, almost invariably editing of the stitched panorama is necessary. Table 1 lists the software I've found especially easy to use for particular tasks. Affinity Photo and PhotoShop Elements both do stitching, but not as well as PTGui Pro. In effect SnapHeal does cloning automatically.

**Table 1**

Name	Use
DxO PhotoLab	Raw file conversion. Image editing before stitching. Panorama editing after stitching.
PTGui Pro	Choosing type of panorama perspective. Adjust chosen perspective. Stitch images.
SnapHeal	Fill gaps along panorama edges. Remove unwanted features.
DxO ViewPoint	Adjusting perspective. Precise cropping to a desired aspect ratio.
PhotoShop Elements	Precise cloning. Adding text.

## 7. Choice of perspective for stitching

Perspective is concerned with how a three-dimensional scene is represented on a two-dimensional surface.

**Rectilinear** perspective assumes the surface is a rectangular flat plane. Straight lines in the scene remain straight, but the corners of the rectangle can "fly away". The angle of view should be less than about 75° to avoid excessive stretching distortion around the edges of the image. Rectilinear perspective is most suited for images of buildings, which have many straight lines.

**Cylindrical** perspective assumes the surface is part of a cylinder (i.e. a drum shape). Vertical straight lines in the scene remain straight in the image, but horizontal straight lines in the scene become curves in the image. Cylindrical perspective works well for panoramas of landscapes (with few or no straight lines) with wide horizontal angles of view.

**Vedutismo** perspective preserves (as straight) straight lines through the vanishing point of the scene. It is occasionally useful for images of buildings.

These perspectives are three of 13 different types available in PTGui. PhotoShop does Rectilinear and Cylindrical.

## 8. An example of a panorama

The photographs immediately below were taken from my bedroom window, using the set-up shown in Figure 2. All three photographs have the camera set at  $f = 29.44\text{mm}$  (=165mm with 5.6 crop factor),  $f/4.5$  aperture and 1/200 second exposure.



### Picture 1

The picture is the result of stitching the three individual images above into a rectilinear-perspective panorama using PTGui.

The black border surrounding the image is deliberate. It shows that the individual images are not very well aligned in the vertical direction.



### Picture 2

The picture is a crop removing nearly all the black border. This is more typical of a crop made from within PTGui.

The black areas are allowed to remain with the intention of filling them in using SnapHeal.

Near the top edge of the picture is a cable. At a point directly above the support pole of a power line is a discontinuity in the cable where the left and middle images overlap.

The size of the image is 8894x5183 pixels (i.e. 46.1 MPx).



### Picture 3

The picture shows the result of using SnapHeal to do two things.

The first is to fill in the black areas.

The second is to remove the cable near the top edge of the second picture above.

What is not very pleasing, however, is the beheaded cow on the right-hand side, the legless cows at the bottom and the missing corner of the two lengths of fence.



#### Picture 4

The picture is a crop using DxO ViewPoint to remove the not-very-pleasing items.

Close examination of the picture discloses that there are discontinuities in the telephone cables just below the tops of the trees. As these cables have no visible means of support they add nothing to the picture and ought to disappear.

Oddly there are no discontinuities in the power cables supported by the pole and cross-bar. They can remain.

These are aesthetic choices and nothing to do with stitching panoramas.



#### Picture 5

The picture has had the telephone cables removed using SnapHeal.

It has also been cropped, again using DxO ViewPoint, to an aspect ratio of width : height :: 809:500. If this aspect ratio is unfamiliar, it is that of the golden rectangle.

The size of this image is 6153x3803 pixels (i.e. 23.4 MPx). It prints on an A3+ sheet at 325 pixels per inch.

Picture 2 has lost 31% of its width and 27% of its height (or 49% of its area) in order to obtain a reasonably pleasing (says who?) final image.

The sequence of pictures demonstrates one benefit panoramas offer. It's not essential to get the subject at exactly the right place in the frame before exposing.



### 9. Convinced about panoramas?

Hand-held, it's easy to take images for a panorama, provided there is enough light.

In some places, for example Carcassonne, Narbonne, Metz and Dunblane cathedrals, indoors is dim and tripods are forbidden. Monopods, however, are viewed as being in the category of crutches for the disabled (trip hazards, but permissible if you insist).

Out of necessity, in 2022 in Dunblane cathedral I devised the way described above of shooting panorama images using a monopod. Out of laziness, I continued to use the monopod method for landscapes in the West Highlands of Scotland, because the camera and monopod assembly is compact and light. This was despite my having with me an all-singing, all-dancing SLR panorama kit.

I happen to like the technical challenge of making large panoramas, but I can quite see why other photographers don't share that enthusiasm. It makes sense, however, for every photographer to know how to make an occasional panorama. Every now and again you can't get far enough back to get everything into the frame, or you've come out with the wrong lens, and so on, *ad inf.*

There is nothing lost from taking two or three digital images hand-held, and stitching them together using PhotoShop Elements. It may not work very well the first time, but you will learn why by doing it. The second time, if you perch your camera on a monopod, it will work even better.

Try it!