

Technical information about PhoToPlan

The following pages shall give you a detailed overview of the possibilities using PhoToPlan.

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Q1 What does 'Image Rectification' mean?

Especially in the sectors of architecture, preservation of historic buildings, building engineering and archeology often the task is to derive geometric information from photographs. On the original photograph the shown objects normally appear distorted because of position and orientation of the camera. For instance on a photograph of a façade this effect becomes obvious at the vertical edges: they converge. In the process of image rectification the photograph will be reorganized and a true to scale image plan is created. On the result image the vertical edges are parallel.



original distorted image



rectified image

Another typical field of application is the correction of scanned maps and plans. Vaults or paper warpage as a result of long time storage or typical scanner errors often cause a bad distortion of the scan. With a rectification it is possible to produce a true to scale plan from such a scan.

Q2 How does image rectification work?

To get a true to scale image plan a digital photograph and reference information from the measuring object is required. That means, it is necessary

to take a defined number of measurements from the object. These measurements can be control points or control distances.

During the rectification process the reference measurements are assigned to the image. With the help of the assignment information the image can be transformed (rectified) arithmetically to a true to scale image plan.

The plane where the reference measurements (control points, control distances) are located is called rectification plane. All parts of the object that are situated directly in this plane are reproduced in true scale on the rectified image, elements that are not situated in this plane remains distorted.

Example façade: You take a photograph of the relevant part of the façade. As reference measurements you choose points or distances that lie within the façade. They are measured by totalstation, tape measure or handheld laser. On the rectified image all elements at the façade plane are shown in true scale, whereas a sloping roof or a balcony remains distorted. They can be rectified in a separate process.

Q3 What do you need for carrying out a photograph rectification?

You need a digital photograph, reference information from the object and the software PhoToPlan. There are two different approaches for photograph rectification. They differ in type of reference information.

- **Photograph rectification by control points**

Control points are fixed on the object. With a surveying instrument (totalstation) the co-ordinates of the control points are measured. Each image must contain at least four control points. All these points have to lie within the rectification plane.

- **Photograph rectification by geometry**

For each rectification three control distances have to be taken from the object. They must be well to distinguish on the photograph. Two of the distances have to run perpendicular to each other. They can be relatively short, for instance like length and height of a window. The third distance is allowed to run at an angle, but should span approximately the whole relevant object.

PhoToPlan is available in two different versions:

PhoToPlan BASIC is the low-cost solution for beginners. It contains the photograph rectification by geometry. PhoToPlan BASIC is suitable for users without a totalstation, because it is possible to gain results with very simple measuring methods. Only a tape measure or a hand-held laser will be sufficient to take the distances.

PhoToPlan is the professional version made for tasks which are very demanding on precision. PhoToPlan contains both approaches: photograph rectification by control points and photograph rectification by geometry. The use of control points allows it to merge more than one rectified image automatically like a mosaic. For measuring the control points it is recommended to use a totalstation.

Q4 What do you have to take into account when taking the photographs?

The following principle applies for all rectification, no matter which camera is used:

The quality of your distorted image is decisive for the quality of the result. If you can not identify the details on the original photograph it will not be possible to identify them in the rectified image.

On principle there are two ways for taking the digital source images:

Either you can use a digital camera or a normal analogue camera. In the latter case you have to digitalize the photograph after taking it. Both methods have advantages and disadvantages. The ideal solution depends on the specific task.

The most important questions are about the image resolution and lens distortion. A lens distortion causes barrel or cushion shaped inaccuracies on the edge of the image. The more wide-angled a lens is, the stronger appears this additional distortion effect. PhoToPlan contains a special command for determination and correction of the lens distortion. By measuring straight lines in the image the distortion parameters are calculated and applied to the image. These parameters can also be stored for certain camera settings for a

reuse. To avoid the lens distortion from the beginning it is recommended to use high quality object lenses with good distortion characteristics.

For digitalization the simplest method is to develop the film on CD ROM (e.g. Kodak Photo CD). Meanwhile many photo laboratories offer this service at relatively low costs. Thus at a standard level you will obtain about 6 million pixels from a 35 mm film negative. Alternatively you can use a usual flat bed scanner to scan in the images on paper, but the image quality decreases with this method.

Q5 Which demands are made on reference information?

For a high accuracy of the rectification three matters are important: The accuracy of the measurement, the mutual situation of the control points or distances and the position of them on the rectification plane.

Photograph rectification by control points

The ideal control points meet the following criterions:

- The accuracy of the points is a factor higher than the required accuracy of the rectification.
- The points lie exactly within the rectification plane.
- The points are distributed evenly on the edge of the relevant object.

If more than four control points are used, PhoToPlan can assess the exactness of the measured points. Errors and inaccuracies can be located and excluded from the result.

Photograph rectification according to geometry

Ideally the following conditions are fulfilled:

- The reference distances lie exactly within the rectification plane.
- Two of the reference distances are perpendicular to each other.
- The third distance spans approximately the whole relevant object.
- Marked vertical and horizontal edges and structures exist on the object.

The better your reference information meets these criterions, the higher the precision of your rectification will be.

Q6 How does the working flow of the rectification with PhoToPlan look like?

Photograph rectification by control points	Photograph rectification according to geometry
1. Reading in control point information automatically or typing in the co-ordinates manually	1. Loading the image to be rectified
2. Defining the rectification plane	2. Putting on the rectification grid
3. Loading the image to be rectified	3. Adapting the rectification grid to the object geometry
4. Assigning at least four Control Points to the corresponding Image Points	4. Assigning the reference measures to the distorted image
5. Defining scale and resolution of the result image	5. Defining scale and resolution of the result image
6. Calculation the rectification parameters. In case of over-determination a statistical test is calculated as well.	6. Rectification process
7. Rectification process	

Q7 How does the rectification of maps and plans work?

A special command allows the rectification and georeferencing of scanned maps and plans.

You will need a digital image of the map and reference information in the form of control points. These points can be either real coordinates from the displayed terrain or just the intersection points of a constructed map grid. The separate definition of a rectification plane is not necessary. The procedure of rectification is very similar to the photograph rectification by control points. But the mathematical algorithm differs from the one which is used for the photograph rectification. The so-called polynomial transformation allows the elimination of typical scanning distortions like irregular scale changes and diagonal or crooked paper warpage.

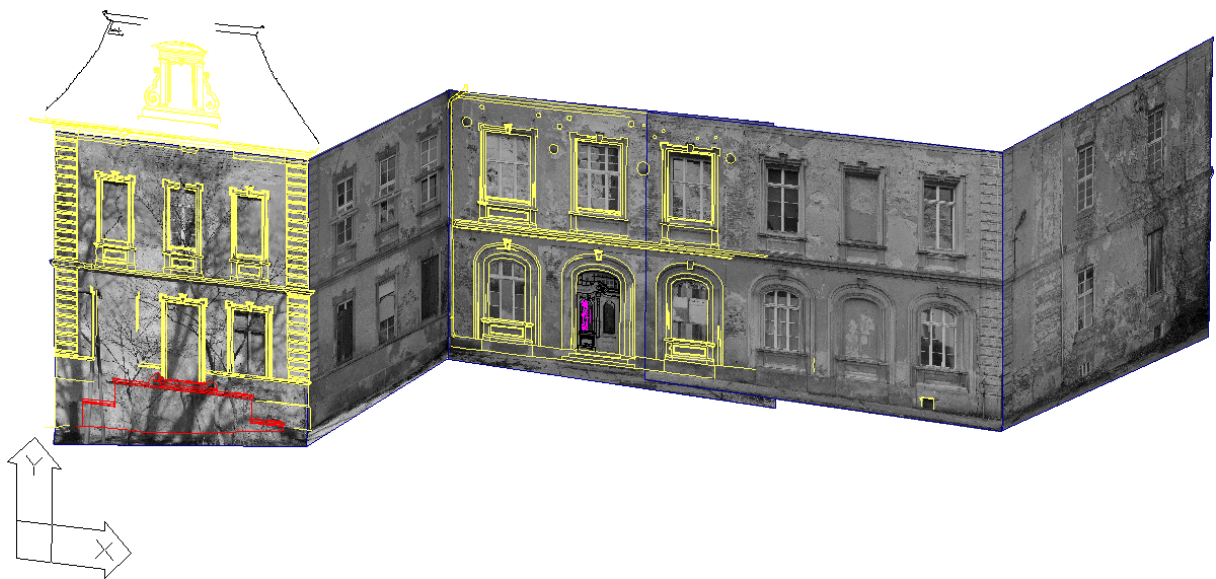
Q8 How the rectified images can be processed further?

CAD systems serve the most extensive possibilities for utilizing the rectified image, no matter whether you want to dimension the image, draw plans of façades from it or calculate areas. With PhoToPlan the rectified image is

created directly in AutoCAD or AutoCAD LT. The utilization can be started immediately without any import or export functions. Additionally PhoToPlan includes functionality for optimized dimension of areas and heights. Of course it is also possible to import the rectified images into other image processing programs. While this the information about image scale will survive.

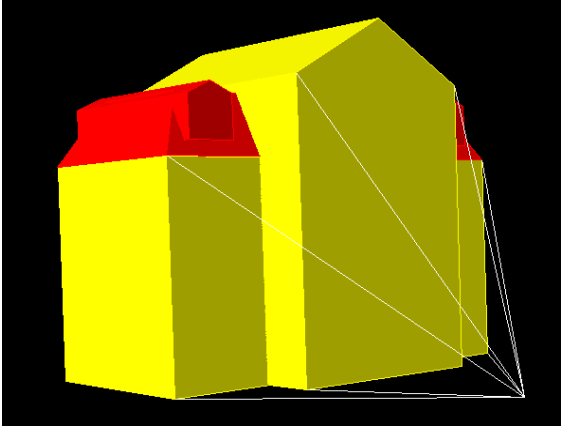
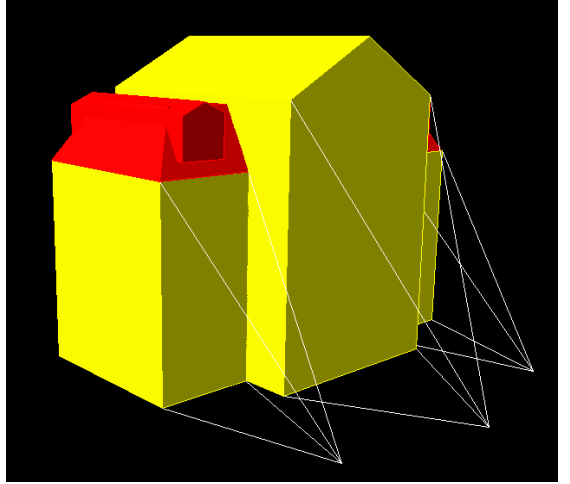

Q9 Can I get three-dimensional information from a rectified image?

No! A rectification is only valid for the rectification plane. That means without any additional information you can not measure three-dimensional coordinates in a single rectified image. But it is possible to divide the object into separate planes and rectify the different parts of the image one by one. The separate rectification planes can be positioned in the spatial room as you like.



Q10 Is it possible to use more than one rectificated images for drawing a plan?

Yes! Therefore you have the following possibilities:

<p>For utilization of a jumping façade one photograph is rectified several times to several rectification planes. Of course that requires enough reference information for every rectification plane.</p>	
<p>To avoid blind angles or to get a better image quality it is also possible to take several photographs from different viewpoints. Each of these photographs is rectified to its specific rectification plane.</p>	
<p>PhoToPlan orientates the single images automatically to each other (only at rectification by control points). If the images are overlapping, you can decide, which part of which image you want to use.</p>	

If required, it is possible to merge the created image mosaic to a whole image.

Q11 What are oriented images?

Oriented images are photos for which the camera's position in space and the direction of the shot are known as well as the focal length and the sensor size. In contrast to rectified images no to scale information can be gained from them directly. But oriented images can be used for dual image evaluation and for 3D drawing with surfaces. Thus they serve to draw 3D geometry.

Q12 What do you need to generate oriented photos?

You need a digital photograph, control points on the object and the software PhoToPlan 3D.

Q13 Which demands are made on the control points for the image orientation?

For a high accuracy of the image orientation the accuracy of the measurement, the position of the control points in the photo and their spatial distribution are important. The ideal control points match the following criteria:

- They are clearly marked on the object and have a number for identification.
- The accuracy of the control points is higher than the desired accuracy of the image orientation.
- The control points **must not** lie all in one plane but should be equally distributed in space. They lie at different depth within the photo.
- The control points are distributed evenly on the image.

If more than nine control points are used, PhoToPlan can assess the exactness of the measured points. Errors and inaccuracies can be located and excluded from the result. If camera parameters are already known the number of control points can be reduced to a minimum of four.

Q14 How does the image orientation with PhoToPlan work?

Image orientation
1) Reading in control point information automatically or typing in the coordinates manually
2) Rotating the drawing is with the help of 3DORBIT, so you approximately look at it like form the camera position.
3) Defining a local user coordinate system (UCS) the XY plane of which matches the current view. Align the control point blocks with this UCS.
4) Loading the image to be orientated
5a) Identification and assigning control points to image points 5b) If necessary determination of the lens distortion parameters.
6) Calculation of the orientation parameters with control and statistical test when being over-determined.
7) Definition of the target path for the oriented image and starting the image orientation.

Q15 What can you use oriented images for?

You may use oriented images for the creation of three-dimensional wireframe models inside AutoCAD. This is an important advantage compared to using rectified images. You can use PhoToPlan 3D to make a dual image evaluation that uses the principle of the spatial intersection of image rays. By clicking corresponding points 3D geometry is created very easily. Using one oriented image and at least one surface, you may generate 3D vector graphics that lies directly on the surface you selected. This for instance is helpful when mapping 3D damages on facades or doing similar jobs.

Q16 What do you need for the dual image evaluation?

For the dual image evaluation you only need PhoToPlan 3D and at two oriented photos. PhoToPlan 3D provides the commands for preparing the screen and for the 3D drawing with two oriented images.

Q17 Which objects can you use as surface for the 3D drawing with oriented images?

You can use AutoCAD solids, meshes, kubit planes and kubit cylinders as surfaces for the 3D drawing with oriented images.

Q18 Which functions does PhoToPlan (3D) comprise and which system requirements are necessary?

System requirements	
platform	AutoCAD version 2007 to 2011 or AutoCAD LT version 2007 to 2011 Windows 2000 / XP / Microsoft Vista (PhoToPlan 3D does not support LT)
Minimum requirement of hardware	like AutoCAD
Required reference information (photograph rectification)	At least 4 control points or 3 control distances
Required reference information (map rectification)	At least 3/6/10 control points (polynomial transformation of 1 st / 2 nd / 3 rd degree)
Required reference information (image orientation)	At least 9/6/4 control points, depending on whether camera information is already available or not.
Supported image formats	All image formats that are supported by AutoCAD, e. g. TIF, BMP, JPEG, PNG
Range of functions	
Rectification of photographs	✓ Projective transformation
Rectification of maps and plans	✓ Polynomial transformation of 1 st , 2 nd , 3 rd degree (not at PhoToPlan BASIC)
Statistical adjustment in case of over-determination	✓ (not at PhoToPlan BASIC)
Definition of the rectification plane	Vertical or free definition
Correction of the Lens Distortion	✓
Further processing of the image using external programs	✓
Clipping the images	✓ with a polygonal boundary
Assembling of several rectified images to an image plan	✓ (not at PhoToPlan BASIC)
Integrated functions for height and area dimension	✓

Integrated area evaluation	✓
Integrated drawing functions	Using the functionality of AutoCAD
Determination of orientation parameters creation of oriented photos (image orientation)	✓ (PhoToPlan 3D only)
Loading oriented images	✓ (PhoToPlan 3D only)
3D dual image evaluation (spatial intersection)	✓ (PhoToPlan 3D only)
3D drawing with oriented image and surfaces	✓ (PhoToPlan 3D only)

Q19 Do you need special knowledge to work with PhoToPlan?

No! At the development of PhoToPlan we attached great importance to a clear design and an easy handling. Rectification does not require special photogrammetric know-how. PhoToPlan uses well-tried program functions which have often proofed their efficiency in practice.

Q20 How you can try out PhoToPlan?

For every interested party we offer the possibility to test our software. The test is free of charge and without any liabilities. You can download a setup on our homepage www.kubit-software.com. Of course you can also request a setup CD. The online manual includes a tutorial. On the basis of practical examples it explains the basic workings of PhoToPlan. You are interested in having a trial? Please contact us. You find your contact data on the first page of this document.