Photogrammetric terminology

Photogrammetry (fotogrammetria, suom.)

The science of making 3D measurements from 2D photographs. With photogrammetric measurements we can obtain reliable information about the properties of surfaces and objects without physical contact with objects, and of measuring and interpreting this information.

Projection center (projektiokeskus, suom.)

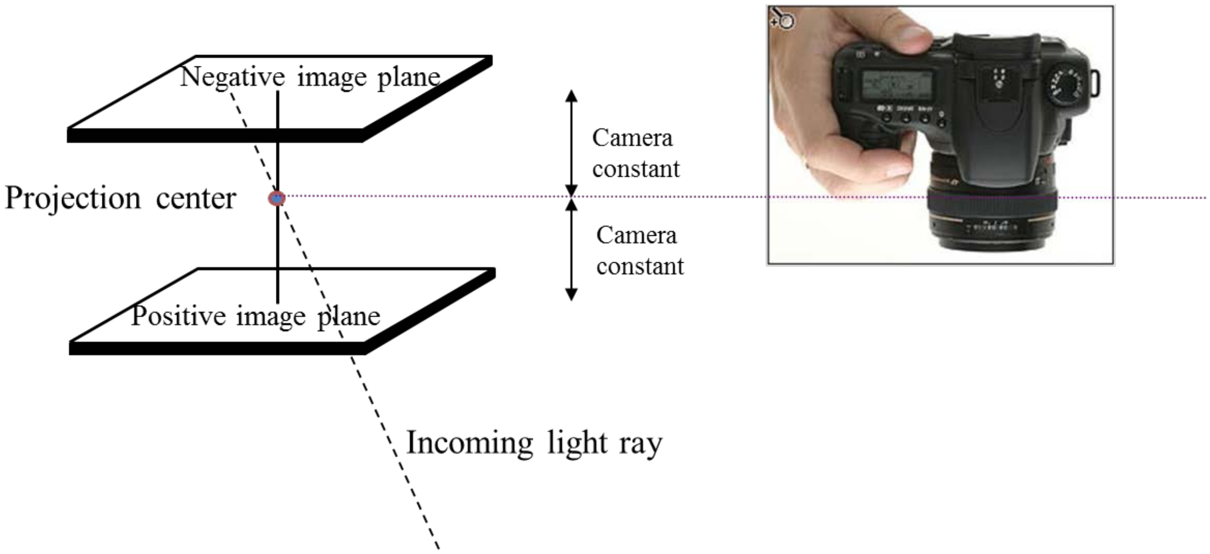
If we had an ideal pin-hole camera, all incoming light rays would go through the projection center. Even if this is not the case with modern lens systems, we are able to mathematically define such center point. This is also the origin of the camera coordinate system (3D).

Principle distance/focal length, f (polttoväli, suom.)

The shortest distance between the projection center and the image plane.

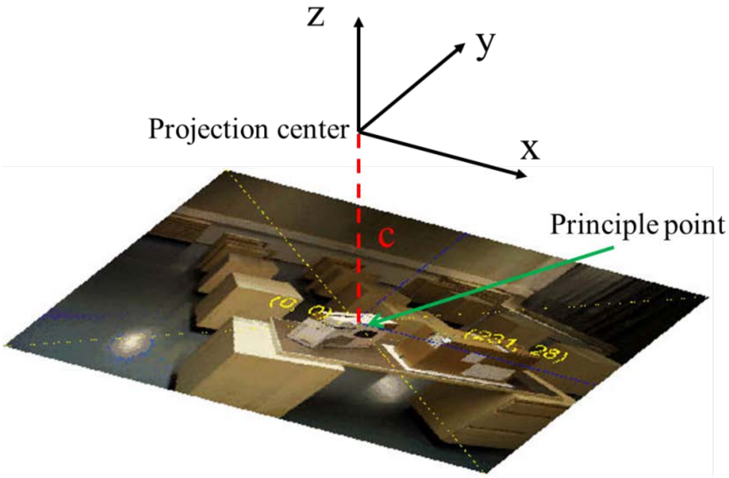
Camera constant, c (kameravakio, suom.)

Usually, equals to the focal length if camera is focused at infinity. Otherwise c<f.



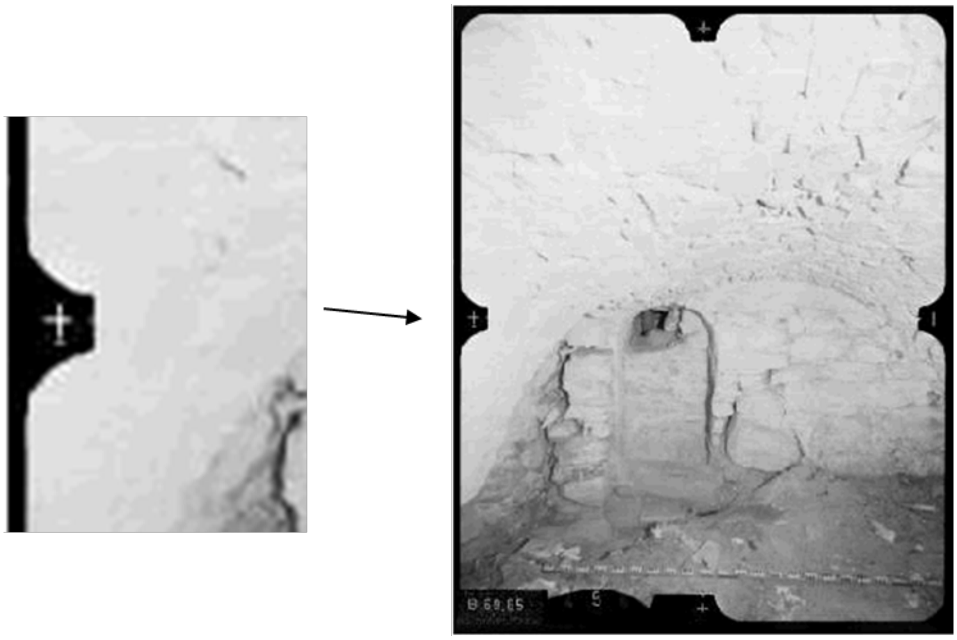
Principle point, pp (pääpiste, suom.)

If we draw a vector from the projection center that is perpendicular to the image plane, the principle point can be found where this vector intersects with the image plane. This is typically close to the center of the image. However, with special lens systems a principle point can locate even outside of the image.



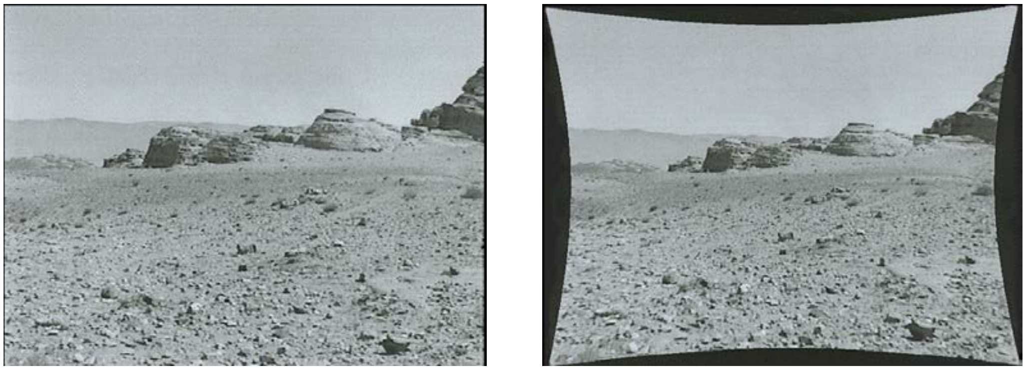
Fiducial mark (reunamerkki, suom.)

Fiducial marks were used in metric analog cameras (film cameras). During the image exposure, fiducial marks always appeared at the same position. Therefore, it was possible to know the image coordinate system and to find the location of a principle point. In digital cameras, there is no need to have fiducial marks because an image sensor creates a natural and stabile coordinate system.



Camera calibration (kameran kalibrointi, suom.)

In camera calibration, we define the internal geometry of a camera. In the ideal case, we only need to solve the location of the principle point and the camera constant. In addition, we usually solve parameters that explain lens distortions.



Left figure: Original image; right figure: lens distortions have been removed and the image corresponds to an ideal pin-hole camera image.

Interior orientation (sisäinen orientointi, suom.)

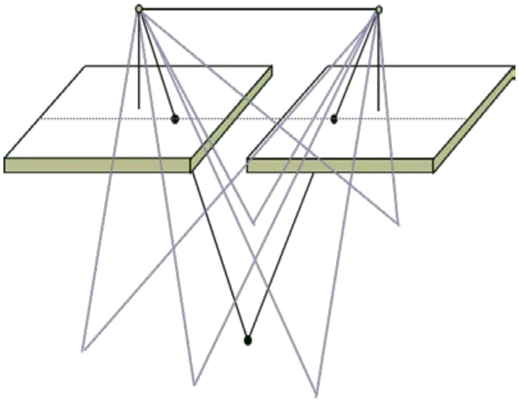
In interior orientation, we solve a coordinate transformation from the 2D image coordinate system to the ideal 3D camera coordinate system. For this transformation, we need to know a camera constant, the location of a principle point and lens distortion parameters. The parameters of interior orientation are known from the camera calibration.

Exterior orientation (ulkoinen orientointi, suom.)

Exterior orientation defines a coordinate transformation between the ground coordinate system (3D) and the camera coordinate system (3D). For this, we need to know the location of a projection center (3 parameters) and three rotations (physically there are several alternatives how to select these rotations) with respect to the ground coordinate system. Typically, solving exterior orientation requires enough known ground control points. Direct georeferencing sensors (Global navigation Satellite Systems and Inertial Measurements Unit) provide exterior orientation information, however, it might not be accurate enough for the most demanding applications.

Relative orientation (keskinäinen orientointi, suom.)

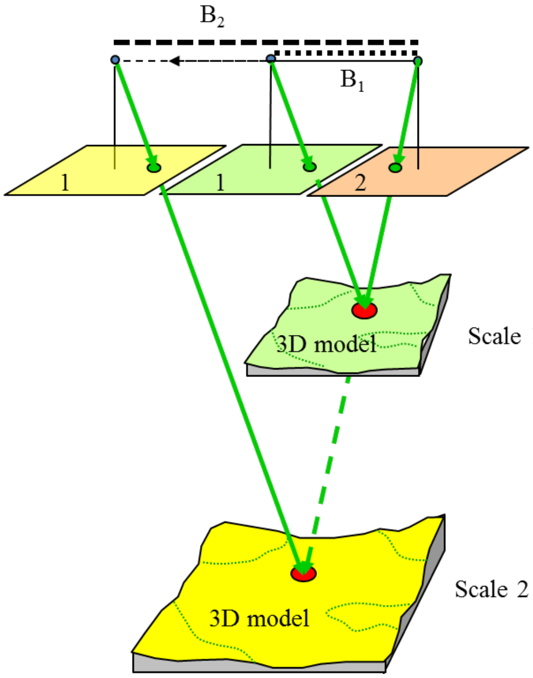
If we have two images, we can solve their relative location (three shift parameters) and attitude (three rotation parameters). Unfortunately, all shift parameters cannot be solved by only using image observations, which leads to that the scale cannot be directly solved in relative orientation. In order to define a scale, we need to have at least one known distance at the object space. Relative orientation can be solved by measuring enough corresponding points or features between images. After the relative orientation is known, we can are able to measure 3D points from stereo image measurements.



Relative orientation

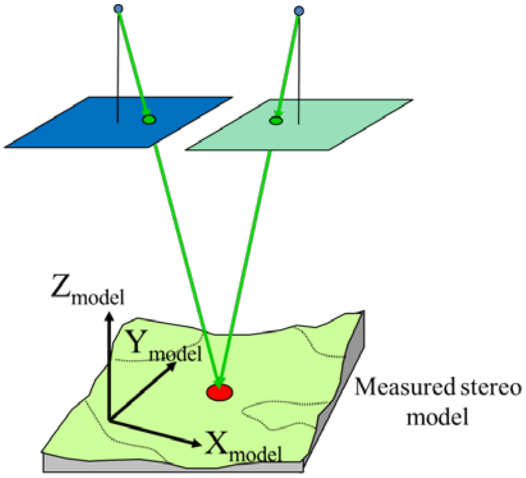
Image base, B (kuvakanta, suom.)

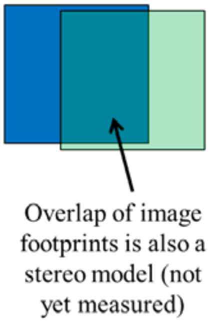
If we have a stereo image pair, the distance (or vector) between the projection centers of camera locations is called as “image base”. If we have done only relative orientation without any ground control, an image base remains unknown (you can set any value to it). Changing the length of an image base, we can scale the measured 3D model.



Stereo model (stereomalli, suom.)

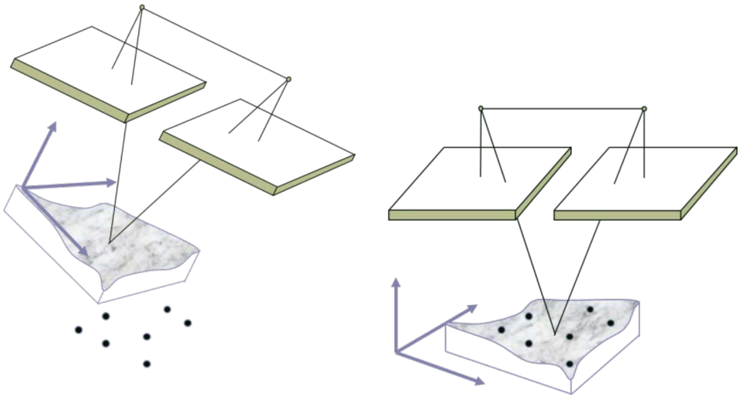
When we have two overlapping images, the overlapping part can be utilized for stereo measurements. The overlapping parts create a stereo model that can be seen in 3D (if images fulfill the requirements of the normal case of stereo imaging). The stereo model part can be utilized for measuring in 3D.





Absolute orientation (absoluuttinen orientointi, suom.)

The stereo model, which was measured from relatively oriented images, is transformed into the ground coordinate system. For this, we have to know ground control points and their correspondence with those 3D points that have measured from the stereo model.



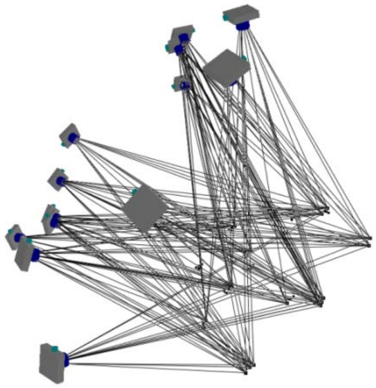
After the relative orientation and 3D measurements, the 3D model is in an arbitrary coordinate system (left image). After the absolute orientation, the 3D model is in the desired ground coordinate system (right image). Black dots represent known ground control points.

Tie-point (liitospiste, suom.)

A point in a digital image or aerial photograph that represents the same object point in an adjacent image or aerial photograph. Tie-points are needed to link images in relative orientation or in bundle block adjustment. Other names for tie-points are corresponding points, conjugate points and homologous points.

Bundle block adjustment (sädekimpputasoitus, suom.)

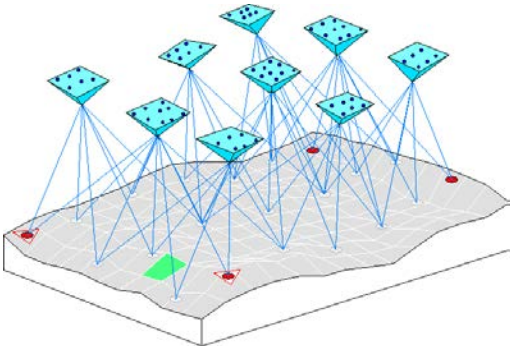
In bundle block adjustment, we use all our image observations (tie-points) in one huge least squares adjustment. In addition, we can include known ground control points and/or orientation information from direct georeferencing sensors (approximate exterior orientations of cameras) in the adjustment. As a result, we get accurate exterior orientation parameters for all images that were included in the bundle block adjustment. In addition, we get new 3D coordinates of all tie-points that we measured between images. If we have a very good imaging geometry of our image block, we can include also interior orientation parameters to the adjustment (camera calibration!).



In bundle block adjustment, tie-point observations establish observation ray bundles that fix the geometry of an image block and object points.

Aerial triangulation (ilmakolmiointi, suom.)

A special case of bundle block adjustment, in which all images included are aerial nadir (vertical) images.



Datum deficiency (datumvaje, suom.)

2D image measurements do not include enough information to solve a 7-parametric transformation (including 3 rotations, 3 translations and one scale) at the object space. This datum problem causes that the design matrix of adjustment has a rank deficiency of 7 no matter how many tie-points we measure, and prevents solving of bundle block adjustment. In practice, we usually use known ground control points to overcome this problem. In a free network adjustment we set fictive constraints to get rid of the datum problem. In this case, the scale and the coordinate system of results are arbitrary.