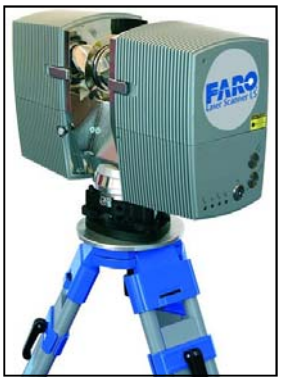
Introduction to Photogrammetry *by Sandy Weiss*

Photogrammetry as defined by Dr. Paul Wolf in his book entitled, Elements of Photogrammetry , is "the art, science and technology of obtaining reliable information about physical objects and the environment through processes of recording, measuring and interpreting photographic images."

There are two distinct types of photogrammetry: (1) metric photogrammetry, involving precise measurements and computations to determine sizes and shapes of objects, and (2) interpretative photogrammetry, involving the recognition and identification of objects. Within metric, applications include (a) aerial photogrammetry and the generation of maps, and (b) terrestrial (close-range) photogrammetry, for the generation of ground-to-ground measurements.

Architects, civil engineers, and archaeologists use photogrammetric techniques for construction, excavation and deviation and/or damage from plans. Accident reconstructionists and law enforcement personnel use photogrammetry for the documentation of accident and crime scenes.



Of course, a laser scanner is the ultimate data gathering tool for the extraction of 3-dimensional data from a site or an object. Major factors in digitizing an accident/incident scene are the speed and quality of the scan. Many users utilize line-of-sight scanning devices, 100 times faster than traditional "time of flight" based scanners. The speed of point capture is 120,000 points per second compared to "time of flight" technology at only 4,000 points per second.

The scanning device documents the necessary area as point cloud data. The scanner recognizes the shade of a reflective surface and builds a 360 degree point cloud with grey scale which results in a black and white image similar to a 3-D photograph. This gives the user a perspective which cannot be achieved through conventional methods such as traditional digital photography.

Line-of-sight laser scanners perform in a non-contact function, and do not interfere with the object being scanned, making it ideal for evidence preservation at the scene of the accident/incident. Scanners can be used indoors as well as outdoors, day or night with no concern for weather and lighting conditions.

When using a camera and total station/theodolite for data gathering, the investigator must know exactly what needs to be documented at the exact moment of documentation. The line-of-sight scanner documents everything. The problem is most people do not have a laser scanner in their go-kit. Lacking this state-of-the-art technology, using a camera as a data input device allows the capture of extensive detail in a short time, and that is what is necessary in investigations and more commonly done.

Photogrammetric practice, tools, and techniques; A photographic image is, for photogrammetric purposes, considered a "central perspective". This means that every light ray passing through or bouncing off the subject before reaching the image receptor (film or digital) during exposure, passed through the camera lens, which in this case is mathematically considered to be a single point (the image/perspective center). In order to take measurements of objects from the photograph, the pertinent light rays must be reconstructed. Therefore, the internal geometry of the camera (the lens focal length, position of the principal point (the projection of the point of sight upon the image plane), and distortion) must be precisely known. The focal length is called the "principal distance", which is the distance of the projection center from the image plane's principal point (The location in the camera where the optical axis of the lens intersects the image receptor).

Depending upon the availability of this technical information, the photogrammetrist is able to place photographic devices into three categories:

Metric cameras: Metric cameras have stable and precisely known internal geometries and minimal lens distortions, by design and

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construction. The principal distance is constant, which means, that the lens cannot be focused when taking photographs. As a result, metric cameras are only usable within the limited range of distances from the camera to the object, determined by the depth of field. The image coordinate system (object data) is defined by fiducial marks, which are permanent markings within the frame of the camera (The marks also appear on the photographs, because the film is held against the glass plate with the marks during exposure.) Terrestrial cameras are often combined with theodolites (for example, total station) to extract base measurements from which to derive unknown dimensions. (See images)

A total station is a combination electronic transit and electronic distance-measuring device. With this device, as with a transit and tape, the operator can determine angles and distances from the instrument to points being surveyed. With the aid of trigonometry, the angles and distances may be used to calculate the actual positions (3-D in space (x, y, and z) coordinates) of surveyed points.

A standard transit is basically a telescope with crosshairs for sighting a target; the telescope is attached to scales for measuring the angle of rotation of the telescope (normally relative to north as 0 degrees) and the angle of inclination of the telescope (relative to the horizontal as 0 degrees). After rotating the telescope to aim at a target, one may read the angle of rotation and the angle of inclination from a scale. An electronic transit provides a digital read-out of those angles instead of resorting to a scale.

The other part of a total station, the electronic distance measuring device or EDM, measures the distance from the instrument to its target.

Stereo cameras: If an object is photographed from two different positions, the distance between the two projection centers is called "base". If both photographs have viewing directions, which are parallel to each other and in a right angle (theoretically) to the base, then they have similar properties to the two images perceived by a human's eyes.

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Member News

FALI President Jim Church appointed **David Batten** as the interim Area 1 Director on January 14th. Mr. Batten, current Sergeant-At-Arms, stated that he will fill that position until such time that FALI can find a replacement. Since Area Director Scott Kamp had to resign due to personal reasons, David and FALI Member **Johnny Huneycutt** of TECO has and will continue to assist with the meetings in that area.

ALL FALI MEMBERS are encouraged to run for office positions of the Board of Directors. The deadline to notify the FALI 2007 Election Committee is February 23rd. Email elections@fali.com or mail to P.O. Box 12483 Tallahassee FL 32317 if interested. Please use return receipt or verify receipt.

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Therefore, the overlapping area of these two photographs (which are called a "stereo-pair") can be viewed in 3D, simulating a person's stereoscopic vision. In practice, a stereo-pair can be produced with a single camera, exposing images from two distinct (and proper) positions or by using a stereo camera.

Normal cameras: A camera is considered normal when the internal geometry is not stable and is unknown, as is the case with any commercially available camera, film or digital. By photographing a test field with multiple control points, at a fixed distance setting (for example at infinity), a calibration of the camera can be calculated.

Photogrammetric Techniques: Mapping from a single photograph, can be accurately accomplished if sufficient known values (control points) exist. The photo must be clear and sharp to yield dimensions with accuracy. Single photographs are also useful for reverse-photogrammetry, where sufficient measurable points exist in both the photograph and in current reality.

Stereo-photogrammetry: As the term implies, stereo-pairs are used as input data. If a single camera is used, two photographs are made from different positions, in an attempt to match the conditions of human vision. Vertical aerial photographs are an example. They are made using metric cameras, built into airplanes and their aspect, by definition, is looking straight downwards. While taking the photographs, the airplane flies over a certain area in a specific way, so the whole area is covered by overlapping photographs. The overlapping part of each stereo-pair can be viewed in 3D and consequently mapped in 3D.

Digital mapping assigns each picture element (pixel) a known position and measured intensity value. The dimensions are gathered for quantitative information.

Mapping from several photographs: 3D plotting is possible from multiple photographs by the use of computers. Multiple photographs are used and 3D objects are photographed from several positions. These positions are located around the object, where any object-point should be visible on at least two and hopefully three or even more distinct photographs.

It is critical to never zoom or re-focus when taking multiple photographs of an object or scene to be used in a photogrammetric project.

Technique: Using known control points and triangulation points the geometry of the whole group of photographs can be reconstructed with **high precision**. Then the image coordinates of any desired object-point measured in at least two photographs can be intersected. The results are the coordinates of the required points. In this way, the 3D object can be digitally reconstructed.

Recommended software and hardware: PhotoModeler Pro is a Windows based software program from Eos Systems, allowing the creation of accurate, high quality 3D models and measurements from photographs. The new release, PhotoModeler Pro 5, offers fully automated camera calibration, support for a variety of file export formats, enhanced photo texturing, and multimedia tutorials to learn to use PhotoModeler more efficiently.

PhotoModeler Pro also has features for extracting data from a single photograph. The features work well even in cases where the camera is unknown. This is useful for forensic applications and accident scene reconstruction.

Pano-Scan has a panoramic camera with photogrammetric capabilities. If it is affordable to you and panoramas of scenes are what you need, it is a wonderful option.

Bibliography: *1) Elements of Photogrammetry, (With air photo interpretation and remote sensing), 1974, McGraw-Hill, Inc. 2) http://www.photomodeler.com/pmpro01.html*

[About the Author: *Sandy Weiss is Coordinator of Corporate Communications at Packer Engineering, Naperville, IL.; FALI Member, and recent speaker at the 2006 FALI Conference, EPIC Board Certified Forensic Evidence Photographer, 2005 recipient of the Nikon Evidence Photographer of the Year Award and 2006 recipient of the Nikon Evidence Photographers Lifetime Achievement Award. Email comments to: slw@packereng.com]*