Photogrammetry

Digital Photogrammetry (”Videogrammetry”) provides the ability to determine the location and shape of spatial objects by means of digital images.
This technique is based on *optical triangulation* (see figure below) and includes the so called ”bundle adjustment” for the determination of 3D-object coordinates as well as all camera parameters (simultaneous calibration) in the same process. For all measurements the simultaneous calibration of the digital camera(s) will be done “on the job”.

A standard photogrammetric measurement procedure can be divided into four broad phases:

- targeting of the object with retro-reflective points
- image acquisition with one or more camera(s) / digital sensor(s)
- image processing (scanning) and
- data reduction plus analysis of the 3-D coordinates.

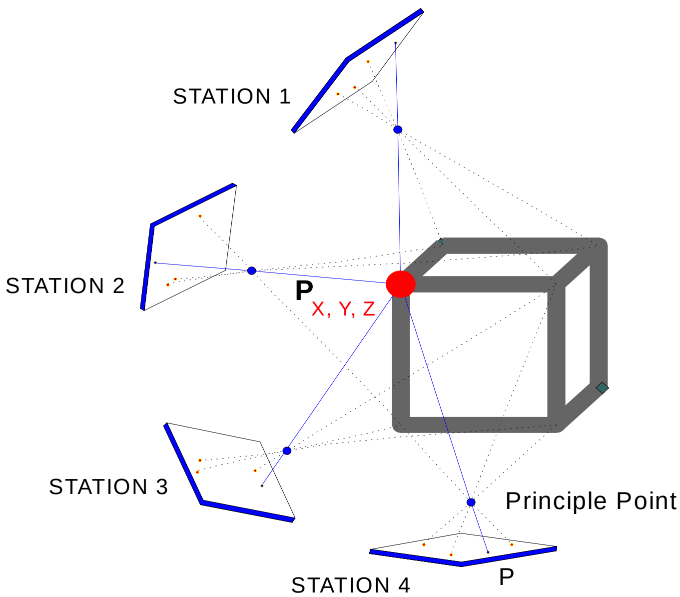


Figure1: *Photogrammetric network with convergent images; the increase of the number of images from different camera locations increases the accuracy and reliability of the results.*

The V-STARS system from GSI

The V-STARS (Video-based Simultaneous Triangulation And Resection System)

A brief description of the V-STARS systems is provided in this document. For a more complete description, please see the product literature available from GSI (www.geodetic.com).

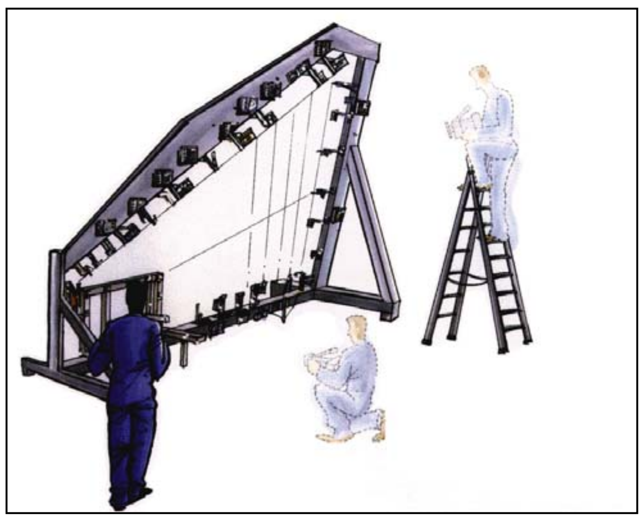
The V-STARS systems are photogrammetric coordinate measurement systems that use single or multiple digital cameras to obtain images. The images are processed to obtain spatial three-dimensional coordinates. The first generation of the INCA camera (**IN**telligent **Ca**mera), was introduced for use with V-STARS in 1996.

There are two basic V-STARS configurations: V-STARS/S, the **s**ingle-camera system, and V-STARS/M, the **m**ultiple camera system.

V-STARS/S System

The V-STARS/S system is an intelligent single camera 3-dimensional coordinate measurement system based on photogrammetry. The S model consist of a notebook computer, a single high-resolution intelligent digital camera (INCA), a V-STARS/S single-camera software license, and some accessories.

The INCA3 camera provided with the S model incorporates a high-resolution digital camera, and an Industrial PC with a built-in PCMCIA interface. The system can be operated in off-line mode or in on-line mode. In off-line mode, images are stored on a removable disk storage card for subsequent processing or the images are transferred via WLAN to the computer.
In on-line mode, the camera is connected directly to the computer (via the optional Ethernet network kit or WLAN) so images can be immediately processed. The achievable accuracy with the system is typically better than 5µm + 5ppm (parts per million).



In operation, the single camera system is used to take pictures of the measured object from several different locations. The different camera locations are needed to ensure all points on the object are seen from enough geometrically diverse locations to get good intersection angles for triangulation. The V-STARS/S system measures retro-reflective target points. High contrast retro-targets make measurement fast, reliable, and highly automatic. The system is immune to instability and vibration. This means the camera can be hand-held and pictures can be taken from a ladder, crane or platform.

V-STARS/S Measurement Features

The single-camera measurement allowed us to demonstrate the use and application of the system for measuring individual targets. The features to note about single-camera measurement in general are:

- The system is immune to instability and vibration. This means the camera can be hand-held and pictures can be taken from a ladder, crane or platform if necessary.
- Part or tool downtime is low because much of the preparation work (setup, targeting, tear-down) can be done on a non-interference basis with production. Then, photography is very fast; usually taking just a few minutes. Also, the camera requires no warm-up time and no time for pre-calibration. You can just unpack it and start taking pictures.
- The system is extremely portable. All components can fit into two small cases that can be carried aboard an airplane. The system's portability makes it extremely well suited to field measurements and on-site inspection at vendor's facilities.
- Although it takes some time to target and measure the object initially, repeat measurements are extremely fast. In situations where the targets can be left on the object, (such as tool stability checks or part deformation studies for example), the repeat measurement takes little more time than the time to re-photograph the object.
- Although sometimes measuring target points is a burden, in other cases it is exactly what you want to do. Measuring the same targeted point each time is often preferable to having to probe in the general vicinity of the point each time. Also, in cases where touching the object is difficult or may cause movement or deformation, the object can be targeted and measured instead.
- Calibrated Feature Targets allow the easy measurement of normal Geometries (Planes, Holes, Cylinders, Corners) and also special designed shapes

V-STARS/M System

The V-STARS/M software extends the single-camera V-STARS/S system and enables multiple INCA cameras to be directly connected to the Notebook computer to produce a real-time measurement system.

The object is photographed simultaneously by two or more INCA cameras from different viewing points. The images are transferred via the Ethernet cables or WLAN to the Notebook where they are immediately processed and the results provided within seconds. The achievable accuracy with the system is typically better than 0,1mm +10ppm.

A non-stable mode is available that allows vibration or movement of the cameras to occur without loss of accuracy. This mode locates the cameras each and every time a set of pictures is taken using a stable field of control points on the object. Thus, movement of the cameras is fully accounted for and of no consequence. Typically, the control field is established by a quick single-camera measurement.

The system can measure individual retro-reflective targets. It can also measure untargeted points using small, wireless, hand held probes that are targeted and have a standard CMM tip attached. Using the pre-defined and calibrated locations of the targets on the probe, it is easy to derive the spatial location of the probe tip. Several different interchangeable probes are available (four are standard, but up to 16 are supported) so you can use the right probe and probe tip for the task at hand. The different probes are automatically recognized by the system. A measurement is triggered remotely using the infrared triggering device provided with the system.