

Basic Photogrammetry

For Crime and Crash Scenes

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Basic Photogrammetry -- Now **there** are two words that really do not belong together! It is like saying basic brain surgery or basic rocket science. Part of the reason for this contention is that most people don't understand the purpose of photogrammetry. To most, it is a black art shrouded in mystery reminiscent of dimly lit musty caverns and bubbling caldrons.

Photogrammetry is used to measure objects from photo-grammes. Photographs are the most common of these but photogrammetry can involve any stored image. The image can be stored on film, tape, disk or electronic media.

The first known use of photogrammetric methods was by a French officer, Aime Laussedat in 1851. Daguerre and Niepce are credited with creating the first "Daguerrotypie" only a decade earlier. Photogrammetry or "remote sensing" is now an integral part of not only the exploration of earth but of space. Remote sensing is a relatively new term that is starting to replace the term photogrammetry, as it accurately describes one of the most important features being utilized -- the capability of two-dimensional or three-dimensional objects to be measured without being physically touched. Since only the reflected light rays from the objects are being recorded there is no interference with or destruction of the object.

There are numerous techniques that can be utilized in photogrammetry and each has unique properties enhancing its ability to accomplish specific tasks under the umbrella of measuring objects. However, the examination of the differences and capabilities of these techniques is not the subject of this article, which will focus on numerical rectification.

Numerical rectification, as the term is used here, is a process used to convert one coordinate system to another numerically. In photogrammetry, numerical rectification is used to "map" various points on a single plane to the desired coordinate system. Digital rectification will transform (digitally) the image into one based on the desired coordinate system. Numerical rectification is simpler than other techniques and the software required is usually much less expensive and easier to use than the software for those other techniques. When dealing with crime or accident scenes, the desired coordinate system is usually a scale diagram, and numerical rectification is ideally suited for this purpose.

Numerical rectification enables mapping to a scale diagram from a single photograph. It requires that four control or calibration points be located on the plane that can be matched to four corresponding points on the scale diagram. The questioned points and the calibration points must all be located on the same plane. While a two-dimensional plane is a prerequisite, this plane need not be a horizontal surface. There is also no requirement that the entire photograph be of a single planar surface.

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Many accident scene photographs are taken to record marks on the road surface. If the distances are relatively short, most of the marks will lie on the same plane. This is not generally true of crime scene photographs. A technique called differential rectification can be used to divide a single photograph into smaller sections that all lie within the same plane. The plane can be a floor, a wall, the ceiling, a tabletop or any two-dimensional plane within the photograph. Each of the planes must be treated separately and individually calibrated, but each may give up vital information through the use of numerical rectification. This article will examine the use of numerical rectification to extract measurements from a single photograph.

Almost all of the photographs involved with both accident and crime scenes cover relatively small distances, especially when compared with the distances of celestial objects. For all practical purposes, these relatively short distances minimize or negate any errors created by lens or camera distortion and make the accuracy of close range photogrammetry quite acceptable for accident or crime scene investigation.

Before exploring the technique of numerical rectification, a discussion of cameras is in order. There are basically three types of cameras used in remote sensing or photogrammetry: the metric camera, the stereometric camera and the amateur camera.

All metric cameras are not necessarily built outside of the United States of America. However, all metric cameras do share certain features, one of which is that the image format is 23 by 23 centimeters. Another shared feature is that the focus is fixed, making metric cameras almost totally useless for general-purpose photography. Also, because of the precision of their internal geometries coupled with the extremely low levels of lens distortions, these cameras are usually very expensive.

The stereometric camera consists of two identical metric cameras mounted so that the viewing direction is exactly 90 degrees from the mount or base. In addition, the cameras are mounted at a precisely known distance from each other, usually 40 or 120 centimeters. The overlapping area of the photographs produced by this method is called a stereopair of photographs and can be seen in three dimensions, effectively mimicking human stereoscopic vision.

Amateur cameras may include the very expensive models used by professional photographers. These cameras have a variable focus distance and therefore unstable internal geometries, which may or may not be recorded on the image. These cameras can be calibrated at a known distance setting, usually infinity, but will never attain the precision of the metric cameras.

Metric cameras are usually associated with “far range” photogrammetry involving aerial or space-related photography. Engineers, architects, archaeologists, surgeons and law enforcement agencies, however, use “close range” photogrammetry to document the status, deformation or damage, and the specific location of objects within the scope of their respective fields. Law enforcement uses close range photogrammetry in the investigation of both crime and traffic accident scenes.

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With this brief introduction into the history, terms, techniques and tools of photogrammetry behind us, the rest of this article will explore its use and show how it will assist law enforcement personnel in their particular fields of investigation. In this effort, common computer software tools will be used that include the Microsoft® Paint program and the two-dimensional photogrammetry (numerical rectification) program within REC-TEC Professional© software.

Requirements for two-dimensional numerical rectification

The basic requirements for two-dimensional numerical rectification are a single photograph and a scale diagram of a two-dimensional surface within the photograph that contains the object that is the focus of the rectification process. Unless the individual doing the rectification is possessed with incredible mathematical skills, a numerical rectification computer program is helpful.

The two-dimensional numerical rectification process provides a method for taking accurate measurements from a single photograph. Four (4) points identifiable on the photograph must be matched with four (4) corresponding points on the scale diagram. Once this is accomplished any points that are in the same physical plane as the calibration points can be placed in the correct position on the scale diagram. The diagram need not be in the same scale as the photograph. The camera, the lens (except a fisheye or extreme wide angle lens), and the position from which the photograph was taken are not of overriding importance as long as there are four (4) identifiable points in the same plane on the photograph that are also on the scale diagram. No more than two (2) of the calibration points (on the photograph or diagram) can be in the same straight line and all of the solution points must be in the same plane.

Step 1

A positive numbered coordinate system must be superimposed on the photograph. Likewise, a positive numbered coordinate system must be superimposed on the scale diagram. The coordinate systems need not be the same scale. Calibration is for one photograph only unless differential rectification is used on different planes within the photograph, in which case each two-dimensional plane must be calibrated separately.

Step 2

The coordinates of the calibration points from the photograph and the corresponding coordinates of the calibration points from the scale diagram are entered into the software. Once all of the points are entered, the software will compute a solution. REC-TEC software is self-verifying, using the photograph points to solve for the corresponding scale diagram points. They must be identical to the entered scale diagram points.