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Focus on Photography

(Part One in a Two-Part Series)

Special Article Reprint about iWitness Close-Range Photogrammetry!

- Fast crime-scene measuring using image-based techniques
- Low-cost and accurate 3D crash-scene mapping from digital images

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Fast crime-scene measuring with close-range photogrammetry

Written by Bob Galvin

A **DICTIONARY DEFINITION** of the word "photogrammetry" offers the following explanation:

> *Photogrammetry is the science or art of analyzing images for the purpose of obtaining good, reliable measurements.*

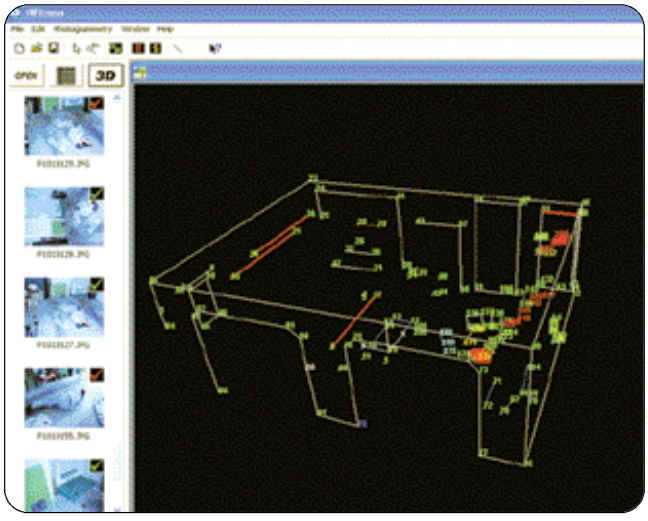
Some people are surprised to learn that this is not a new science or art. One of the first documented cases of its use occurred around 1492, when Leonardo da Vinci used glass lenses and the principles of geometry and perspective to reproduce a subject with accurate measurements. Three-hundred-and-sixty years later, during the Civil War, the Union Army put cameras in observation balloons to conduct reconnaissance of the enemy territory. And topographical information about the Moon and Mars has been gained—without humans ever setting foot there—through the use of the principles of photogrammetry.

Today, crime-scene investigators use photogrammetry to obtain highly accurate measurements when they are documenting compact scenes. Thanks to the aid of digital-camera systems and customized software, this technology is becoming a preferred 3-D data-mapping method among experts.

Traditionally, the most straightforward and obvious method for obtaining measurement data at a crime scene or an accident scene has been the use of tape measures. From a multitude of one-dimensional measurements with a tape measure, 2-D and 3-D drawings can be constructed. Unfortunately, this method can be tedious—and in certain situations, it simply cannot be done. Examples of situations where physical measurements may not be easy to obtain include scenes that have numerous items of evidence; scenes processed in unfavorable weather conditions; or when the investigator

Here is how photogrammetry is used

The iWitness software program was designed to facilitate diagramming of complex crime scenes from information provided in photographs. In this computer screen-capture, you can see the non-contact 3-D object points (the tiny color squares) of the murder victim and surrounding evidence.



The data from the photo on the left was taken into the iWitness software to provide a 3-D graphics view of the points and lines that make up the crime scene. As you can seen, all salient information is present, ready to be exported to a CAD diagramming package.

or evidence technician is working alone or without proper equipment. In these cases, a camera can quickly capture the needed information—and at a later time, a skilled person can go back and calculate measurements at the scene based on the photographs.

By using surveyors' total stations, crime-scene investigators and accident reconstructionists have a way to directly measure the X, Y, and Z coordinates at a scene. This method has enhanced the prospects of utilizing low-cost computer-aided drafting (CAD) diagramming software such as Crime Zone, a product developed by The CAD Zone, Inc. to analyze the scene and generate drawings and graphics for documentation purposes. While the surveyors' total stations have been considered valuable for 3-D measurement technology, they still display a significant operational shortcoming: measurement is relatively slow and can be rather skill-intensive for complex crime-scene reconstruction tasks.

During the past few years, crime-scene reconstructionists have increasingly used digital technology to perform photogrammetric techniques. Here is how the process works:

This sophisticated technology used to be the domain of highly skilled specialists ...but with the development of new imaging software, close-range photogrammetry is openly accessible to the non-specialist user.

Multiple, overlapping images of an object or scene are captured by means of photography. Then, the positions of feature points between two or more images are referenced. Finally, the X-Y-Z coordinates of those feature points are calculated using photogrammetric triangulation.

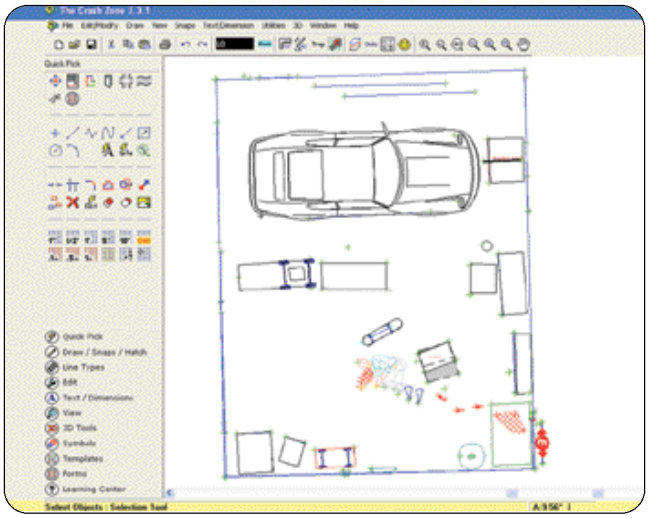
Photogrammetry used to be the domain of highly skilled specialists, primarily because the process involves complex mathematics. Today, because of the development of new imaging technology and algorithms, close-range photogrammetry has become accessible to the non-specialist user. Therefore, anyone with an off-the-shelf, consumer-grade digital camera and a state-of-the-art photogrammetric data-processing system can obtain 3-D measurements with accuracies on the order of 1:4,000 to 1:10,000 of the main dimension of the scene being recorded. In crime-scene reconstruction, accident reconstruction, and forensics applications, this means that it is now possible to position feature points that are accurate to within about one inch on scenes that cover several hundred feet.

A quick way to archive evidence

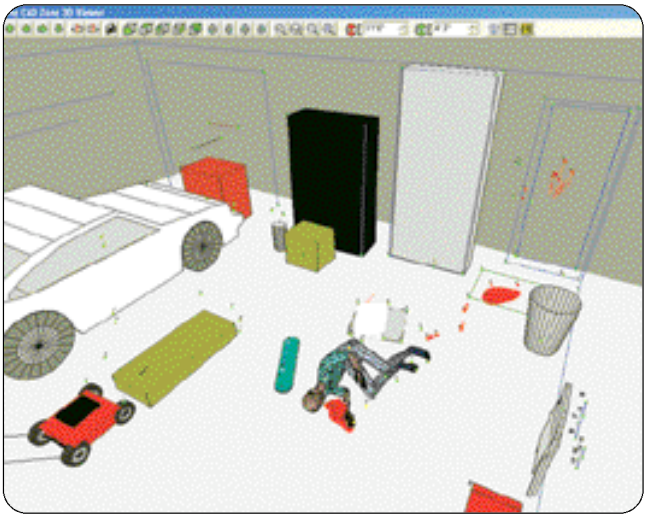
Photogrammetry offers many practical advantages for crime-scene reconstruction. Chief among these is the fact that images can be recorded very quickly, minimizing the time spent at the scene of an incident. The imagery provides a permanent and irrefutable visual record of the scene. This crime-scene imagery can be translated into 3-D measurements at any time in the future.

Furthermore, with correct field procedures, photogrammetry offers a reliable measurement tool because of the data redundancy that is inherent in multi-image coverage of the crime scene. Low cost is yet another advantage

to accurately portray a crime scene



The photogrammetry data from the iWitness program has been brought into The Crime Zone diagramming program and is displayed here as a plan view. At this point, the operator will apply the appropriate symbols from The Crime Zone diagramming menu.



When the symbols have been applied, The Crime Zone diagramming program begins to work its magic, converting the data into an isometric view of the crime scene. This is a graphic image that can be rotated and zoomed to illustrate information to a jury.

of photogrammetry. The total cost for a system that consists of a suitable digital camera and close-range photogrammetric system is about $2,000, or roughly 20 percent of the cost of a surveyors' total station.

A vital component of the close-range photogrammetry system is the PC-based image-analysis and data-processing software. Since most crime-scene reconstructionists are not photogrammetrists, the software needs to be easy to operate and reliable. It must also feature robust photogrammetric image orientation and 3-D feature-point determination processes.

The iWitness photogrammetry software program is the most recent entry of affordable measurement and mapping tools available. This program was co-developed by Photometrix Pty Ltd with DeChant Consulting Services - DCS, Inc.

The iWitness software is specifically designed and optimized for accident reconstruction and forensic measurement.

Alternative software programs, facilitate complex 3-D modeling with image draping and texturing; that are designed to assist with more general photogrammetry applications. The iWitness program was designed to provide maximum ease of use, minimum program controls, and maximum reliability and process automation.

Case Study #1:
Ideal for tight crime scenes

Before joining the Arizona Department of Public Safety's (AzDPS) Vehicular Crimes Unit, Officer John Allen quickly saw the benefit of using photogrammetry for the department's crime-scene investigations. He felt this technology would work well on cold cases as well as for shooting scenes.

"One of the problems we have with a shooting scene that is inside a building is that surveyors' total stations are pretty cumbersome and are not as easy to use as they would be on an outdoor scene that is more spread out," Allen said.

The AzDPS currently uses the iWitness photogrammetry software program. "The iWitness program is very easy to use," said Allen, who indicated that the department had previously worked with a different photogrammetry program but found it was slow and difficult to use. "There are significant time savings with this current software (iWitness) over having to use other equipment to take standard measurements of a crime or crash scene," he noted.

Another interesting way the officer uses iWitness is for tactical planning in building interiors where distances and angles must be obtained in a covert manner.

"I felt we could use iWitness to go through a building and take some covert photos of key locales, and maybe even do some fly-bys with a helicopter," Allen explained. Then, using a diagramming program installed on the department's desktop computer, the officer would be able to build a diagram telling sharpshooters where potential targets might be, as well as specific shooting distances.

Case Study #2:
Photogrammetry aids diagramming

Officer Danny Hannigan, Allen's partner at the AzDPS, works accident reconstruction involving homicides or aggravated assaults. He sees photogrammetry as the primary measuring system for Arizona highway collisions. According to Hannigan, the iWitness program's mapping- and measurement-analysis capabilities, fused with a drawing program's data-import feature, enables the diagrams and the crime-scene photographs to be viewed simultaneously. This melding of technologies also provides highly accurate crime-scene diagramming.

"When I am drawing my diagram, I am actually drawing my points and connecting them," Hannigan explained. "I am doing the work on the photographs—physically seeing the points that I am connecting. When I download points from hardware measurement systems—such as GPS or total stations—I'm just seeing the points in a black background. Here, with photogrammetry combined with a drawing program, you can actually see what you're looking at. I find this to be a major asset of photogrammetry."

Not only does Hannigan feel that photogrammetry will be a quicker and more reliable method for measuring scenes of fatal collisions, but he also considers it a boon to future court presentations on collision cases.

"With this program, I can defend my diagram because I'm drawing it off the photographs," Hannigan said. "I can see how the diagram fits the photographs." He added that in prior trials, questions have come up as to the positions of poles at vehicular homicide scenes where total stations were used. If these poles are not completely vertical, he said, you can be off by an inch or so. With photogrammetry, Hannigan added, "There's a lot less explanation involved. I can show the court the photographs I used and how I drew my points."

The AzDPS uses the Crash Zone and Crime Zone diagramming programs—both from The CAD Zone—along with several other drawing programs, some of which were not designed exclusively for the law-enforcement field. The CAD Zone programs tailor their functions and capabilities particularly for crime- and crash-scene investigations. And, like the AzDPS' other drawing programs, these will import 3-D point data in .dxf or ASCII format.

Case Study #3:
Fast drawing programs are vital

It was in conjunction with Corporal Robert McKeown's use of the Crash Zone three years ago—as an officer for the Florida Highway Patrol (FHP)—that he was introduced to photogrammetry. McKeown had been using The Crash Zone consistently for the state's high number of fatal highway collisions in Orange and Osceola counties, which average about 168 annually. The trouble was, traditional measurement systems being used at the time kept roads and freeways locked down for two to three hours. As a result, cars backed up, drivers became angry, and secondary accidents were routine.

Then, McKeown said, the FHP incorporated photogrammetry. As with any new technology, there was a learning period that the FHP had to go through. Before ultimately choos-

ing iWitness, the highway patrol worked with an alternate photogrammetry program—but they found it was geared more for survey work than for accident reconstruction. After using iWitness, patrol officers noticed significant time savings and ease of use.

"For close-range scenes, it's fast," McKeown said. "I can set up markers on the scene, take photographs quickly, pick up my markers, and I'm done in about half the time it takes using typical measurement methods."

McKeown uses iWitness for vehicular homicide scenes that cover less than 350 feet. "It is quick, does the job, and it is accurate," he said. "Also," he added, "the more data points collected by a user of photogrammetry, the more accurate the measured scene will be once it is diagrammed."

McKeown has experimented with numerous drawing programs, but he feels The Crash Zone and The Crime Zone work best with the FHP's new photogrammetry program. These drawing programs, which are bundled together and sold as one software package, feature improved data import capabilities, allow measurements to be entered more quickly, have an expanded symbols library, and feature a more powerful 3-D viewer. The 3-D viewer now creates 3-D surfaces of sloped roadways for crash scenes, and shows details of important evidence, such as bloodstains on walls and other vertical surfaces.

"The Crash Zone gives us the best of both worlds," McKeown said. "It gives you speed in building a diagram if you've got to get that diagram done because you're going right to another traffic accident after the one you're working. And I can rely on Crash Zone to give me a pinpoint accurate diagram that can be used in reconstruction work and that can be taken to court."

Case Study #4:
Maps on the ground and in the air

It is impossible to imagine how some crime scenes could ever be measured and diagrammed without the powerful aid of photogrammetry. That is the opinion of Captain Bob Anderson, of the Utah Highway Patrol. Like his fellow highway-patrol officers nationwide, Anderson has used total stations to map accident scenes. He recalls one incident that became a crime of passion. A husband came home one day to discover his wife and her boy-friend in the bedroom. The husband grabbed a gun and began shooting, killing his wife and wounding the boy-friend. The boyfriend fled the house, running into backyards, down alleys, and through front yards of other homes in the neighborhood. As the boyfriend desperately ran from one home to another, knocking on neighbors' doors and splattering blood on each door, the angry husband began driving his van down the street, shooting at the boyfriend whenever he spotted him.

"With just a total station and no photogrammetry, trying to map and measure that scene would have been a nightmare because there would have been multiple station moves," recalled Anderson. "We did ground-based photogrammetry for blood-spatter mapping on the homes' front doors and blood mapping in the front yards. We also conducted bullet trajectory studies, and generated interior plot diagrams of the evidence.

"We used our digital cameras and aerial photogrammetry photos (taken from a low-flying helicopter) to map the perimeter of the homes and other adjacent land markings that were part of the case," he added.

Based on this experience, said Anderson, photogrammetry is not only a great tool for accurately measuring and mapping complex crime scenes, but it also preserves evidence in a way few other measurement methods can.

"Once you have left the scene, you can't go back because the scene has been contaminated," explained Anderson. "With photogrammetry, we can often utilize the pictures of the scene and measure things that are important to us later on, or that maybe we didn't recognize as being important at the time when we were mapping the scene."

The archival recording capability of the iWitness photogrammetry program is crucial, mainly because many crimes scenes become cold-case files that may lie dormant for years until they are re-opened. It is a feature that no doubt will resonate with juries.

"When you show a jury the real pictures of a real scene, when it happened, and the actual measurements made on the pictures—that holds a lot more weight than using other tools for measurement-mapping," said Anderson. "You can actually use photogrammetry to take the jury to the crime scene." mmm

The author of this article, Bob Galvin, is a freelance writer who writes for a number of law-enforcement publications. His office is located in Oregon City, Oregon. Galvin can be reached by e-mail:

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For more information about the iWitness software, you can visit this website:

www.iwitnessphoto.com

For more information about The Cad Zone software, you can visit this website:

www.cadzone.com

For information about the iWitness Close-Range Photogrammetry software program or the Crime Zone / Crash Zone diagramming program, please use the following contact information:

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