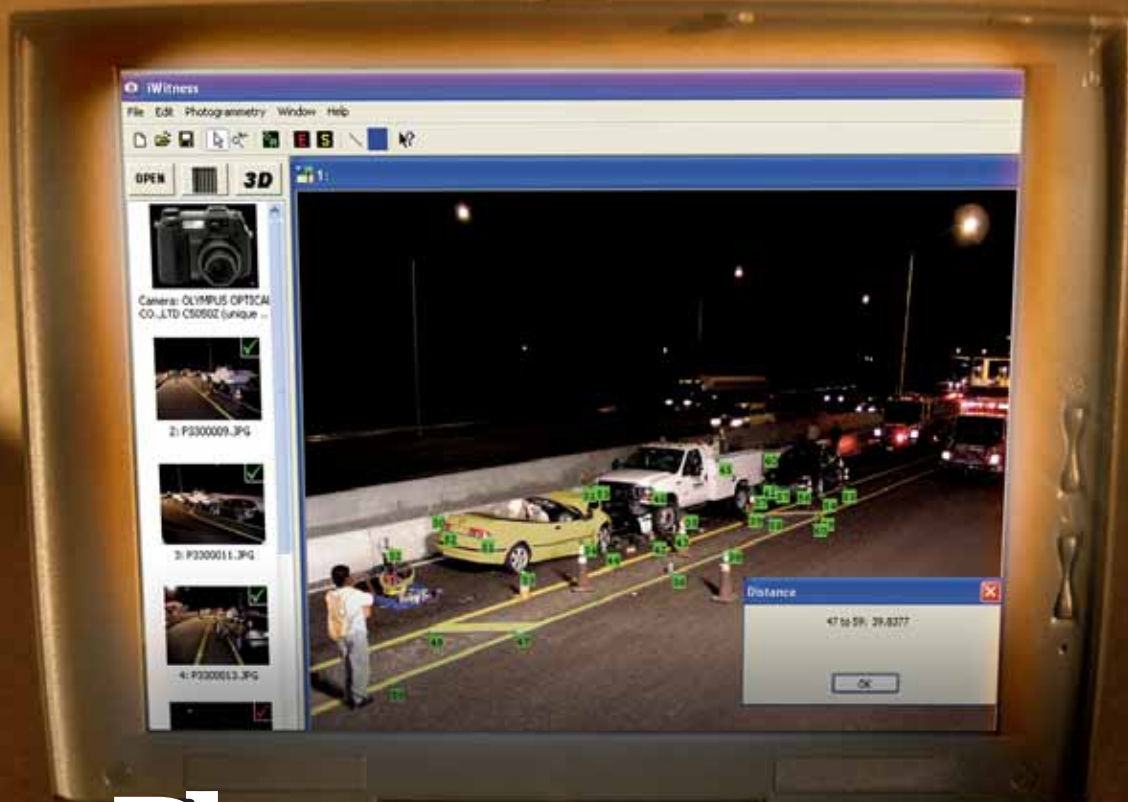


The Crash Zone iWitness program plots notable points in a crash scene.



Photogrammetry Mapping for *CRIME SCENES*

BY BOB GALVIN

A tool exists that can map crash and crime scenes, delivering accurate measurements in far less time than conventional methods. It is called “Close-Range Photogrammetry.” With this technology, 3D measurements can be extrapolated from 2D digital camera images acquired from various angles at the scene. These are then fed into special

software, which processes the data points captured and produces a 3D model. The 3D photogrammetry modeled points and lines are then converted into a 3D diagram using a CAD (computer-aided) drawing program.

Until the introduction of photogrammetry, the traditional method for securing measurement data at an accident or crime scene has long been the tape measure and distance-measuring wheel. From a multitude of one-dimensional measurements taken with a tape measure, two and three-dimensional drawings can be constructed.

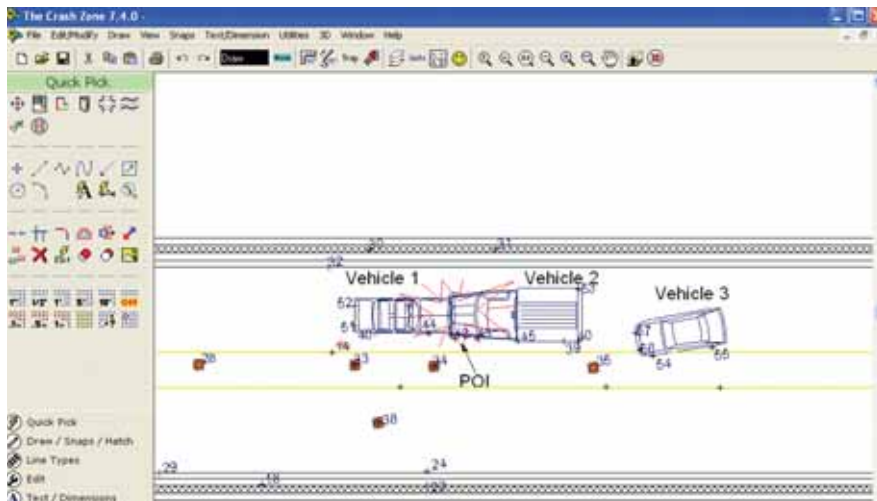
Unfortunately, this method can be tedious, and in certain situations it simply cannot be done with the required accuracy. Examples of where physical measurements may not be easy to obtain include: scenes having numerous items of evidence; scenes processed in unfavorable weather conditions; or when the investigator or evidence technician is working alone or without proper equipment.

In such cases, a digital camera can be used to quickly capture the necessary scene details and evidence. Later, a skilled person can calculate

measurements based on the scene's digital images. It is from this application that Close-Range Photogrammetry, or Digital Photogrammetry, has been successfully applied to crime and crash scene investigations.

Brief Road Closures

In the last 15 years, police have deployed new tools to reduce time needed to conduct on-scene investigations and to create better scene diagrams. These tools include the use of expensive electronic distance measuring devices such as the Total Station and, most recently, Laser Rangefinders equipped with angle encoders for the 3D measurement process.



Both of these methodologies have resulted in more comprehensive scene measurements and better diagrams than traditional tape measurement methods. However, delays in getting these devices to the scene, the instrument setup, plus data acquisition time can quickly negate their effectiveness, thereby creating lengthy road closures.

Studies have shown that the longer traffic is delayed the more likely motorists are at risk of injury and fatality as a result of secondary incidents. Furthermore, police and DOT agencies are subjected to increased risks of safety related litigation from the public as a result of long road closures. Idled traffic leads to millions of dollars of lost revenue in commerce, wasted fuel, and increased air pollution.

Fast Image Capture

To avoid these hurdles, numerous US

state and local police agencies have turned to close-range photogrammetry, which can reduce the incident time by utilizing digital cameras to "map" the scene with photogrammetric-image mapping techniques. Police officers have, on average, reduced the on-scene mapping time by 50% using photogrammetry.

Why should law enforcement agencies consider photogrammetry? The primary benefit is that images can be recorded quickly on-scene, minimizing time spent at the incident scene. The scene and resulting 3D measurements are permanently archived using a modestly priced digital camera in combination with a special photogrammetry software program.

Measurements can be made months or even years after an incident.

The images created an irrefutable recording of the three-dimensional measurements of scene evidence for CAD diagramming, particularly useful for litigation.

The cost to implement photogrammetry is low relative to other mapping techniques. By employing a digital camera and a photogrammetry software system, an agency can spend only about \$2,000. This is one reason that photogrammetry is gaining widespread acceptance among law enforcement agencies for crime and crash investigations.

Simple Software

An essential component of a close-range photogrammetry software program is the PC-based image-analysis and data processing capability. Most crime scene reconstructionists, forensic technicians,

CALIBRATING CAMERA FOR PHOTOGRAMMETRY

If you choose photogrammetry to map any of your crash or crime scenes, you'll naturally need a high-quality digital camera. Before you can begin taking photos of a scene, it's a good idea to calibrate the camera to ensure the highest accuracy of measurements that will be derived from the items photographed. Calibration is not essential, but it's a nice safeguard.

Once your camera is calibrated to accomplish image measuring, the photogrammetry program should be able to update the database with the new calibration values. This step, performed automatically, should enable you to then use your camera for regular photogrammetric measuring of any scene and achieve high 3D measurement accuracy.

The photogrammetry program should have most of the manufactured brands of cameras in its database so that calibration can be accomplished. There can be several ways to calibrate a camera, and any one photogrammetry program may handle it differently.

If calibration really isn't essential, then why do it? Simply because the integrity of your data will be higher quality if you do calibrate the camera. More importantly, the higher integrity of your data, the better chance a completed 3D diagram generated with the data on a drawing program will be accepted in a court proceeding.

Finally, calibration is really just part of the whole goal of achieving measurement accuracy and data integrity. Consider these other principals tied to 3D accuracy in close-range photogrammetry:

- Minimum one accurate scale distance measured on scene
- Minimum five-pixel digital camera
- Use the camera's highest image resolution
- Acquire high quality image overlap at the scene
- Use automatic target centroid marking in the image marking phase
- Use a time exposure of at least two seconds for nighttime imaging

and forensic scientists are not photogrammetrists. Therefore, the software's functionality must be intuitive, allowing the new user to generate the 3D modeled photogrammetry points and lines needed to create an accurate scene diagram. The user simply needs to 'point and click' the mouse and the Photogrammetry is per-

choice. McKeown, who has been on the FHP force for eight years, four years of which he has spent handling homicide investigations, has used iWitness for just over one year. He likes the program because it is designed exclusively for use with forensic scenes, incorporating a highly automated image-marking process

program on a desktop or notebook computer whenever it is convenient, long after the scene has been re-opened to traffic.

The investigator imports the camera's digital images into the photogrammetry software program and then marks corresponding feature points between images to determine the 3D coordinates. The X-Y-Z coordinates of the identified points are automatically calculated by the software using the principles of photogrammetric triangulation. Then, the photogrammetric 3D model can be imported into one of a variety of CAD systems to complete a diagram.

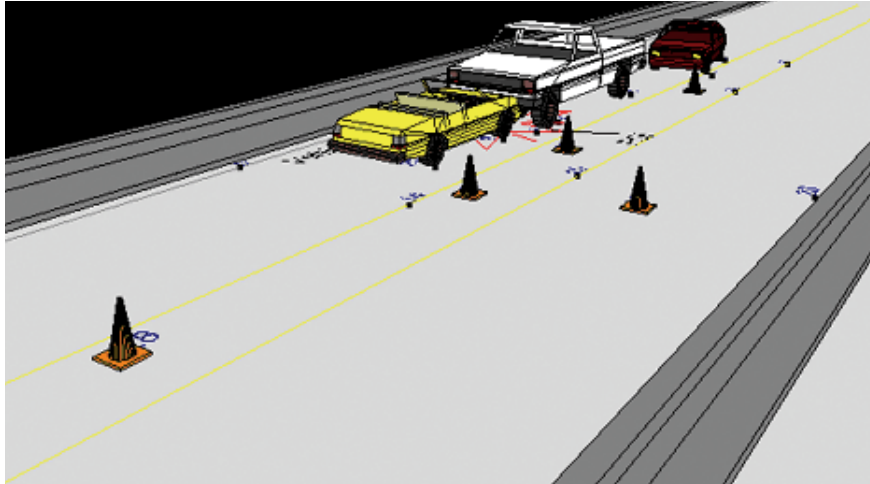
Remember that no CAD drawing programs exist that perform photogrammetry. However, some drawing programs are able to import 3D data, in the .DXF format, from a photogrammetry program and create a 3D model. Among the many programs that can accomplish these drawing tasks are The Crash Zone and The Crime Zone from The CAD Zone, Trancite ScenePD, MapScenes and Visual Statement Vista FX.

Compatibility between photogrammetry and drawing programs is important, even though it is often a matter of personal choice as to which CAD program is selected. With these drawing programs, a 3D model can be quickly generated from a plan view diagram just by adding symbols to the photogrammetry points. With the click of a button, the points and symbols are converted into 3D, where they can be viewed from any perspective angle.

Measurements Equal Total Stations

A significant aspect of close range photogrammetry is that once the digital images are acquired, and the computer work accomplished and a 3D diagram generated, the accuracy of the results is impressive. According to Oregon State Police Officer Jim Pierce, who works with photogrammetry, "Our measurement results have been very positive, and right-on with the total station measurements."

In fact, Pierce, a trained reconstructionist, whose state patrol also has been using the iWitness software, said he used the program to measure a scene that was more than 600 feet. He reports that measurements matched up perfectly with those recorded for the same scene using a total station. The Oregon State Police is still



The 3D image of the crash scene is courtesy of Crash Zone.

formed seamlessly in the background by the software.

Sergeant Bob McKeown, of the Florida Highway Patrol (FHP), is an avid user of photogrammetry. No wonder since Florida has one of the highest number of vehicular homicides in the country. In fact, there is even an open roads policy between the state

Department of Transportation and the FHP for troopers to clear accident scenes and re-open roads within an hour and a half of an incident.

"We wanted a mapping method that would allow us to open roads quicker for the Florida turnpike," McKeown said. "We use the baseline tape as our primary method, and sometimes total stations, but both these tools take a long time, and have proven to be really slow. After trying one photogrammetry program, we found it difficult to use for the computer processing work and quite time-intensive, but we remained interested in the photogrammetric approach, as it is far faster on-scene and less expensive," McKeown said.

The Florida Highway Patrol ultimately adopted the iWitness close-range photogrammetry program as their preferred

and a rigorous photogrammetric camera orientation capability, making it fast and reliable to use.

"Initially, I had used iWitness on short scenes," McKeown said. "Typically, I can do a scene in about 15 to 20 minutes and be out of there." Two noteworthy features of the photogrammetry program that the sergeant particularly likes are that the software automatically "target centers" markers and "target offsets" the points of a given distance, which is particularly useful for measuring items like evidence markers and traffic cones.

"The iWitness program can measure a scene over 500 feet long with gradient change, which we find to be a very attractive feature for our diagramming," McKeown said.

Close-Range Photogrammetry

Just what are the steps to turn pictures into an accurate scene diagram? The process typically begins once the police investigator acquires overlapping images using a digital camera at the accident scene. The digital images are used later to measure and model 3D feature points from evidence at the scene. The measurements are not obtained on-scene, but are calculated by using the photogrammetry

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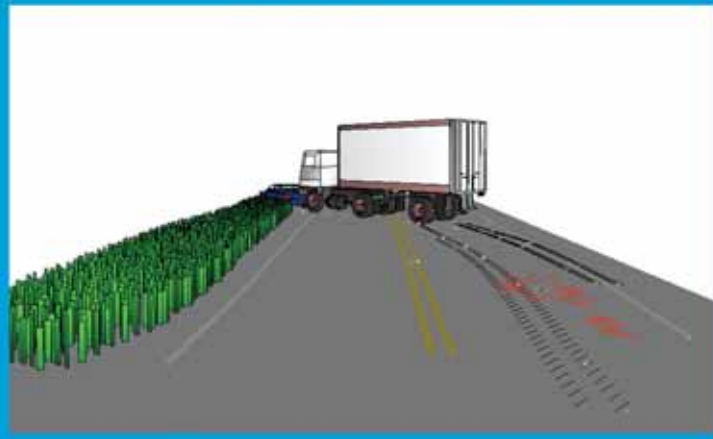
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testing photogrammetry's functionality in different situations such as varying weather and lighting conditions. "We not only have to use the photogrammetry program in these environments, but we use it in many cases to back up, or in combination with, the measurements we do with the total station," Pierce said.

The landscape of software programs aimed at accident reconstruction in close-range photogrammetry is varied. Therefore, it's important to pick the program that best fits your application given the number and complexity of scenes you need to measure, and whether they are crash scenes or crime scenes. Among a few of the programs are:

iWitness is a close-range photogrammetry software system co-developed by DeChant Consulting Services of Bellevue, WA and Photometrix Pty Ltd, Melbourne, Australia. iWitness was developed primarily for accident reconstruction and forensic measurement. This program features high levels of photogrammetric process automation and ease of use for both non-specialists and reconstructionists.

PhotoModeler was developed by Canada-based Eos Systems. This photogrammetry program also enables the user to take measurements and create 3D models from camera imagery. PhotoModeler is positioned as a one-size-fits-all photogrammetry program designed for use in accident reconstruction, architecture, archaeology, engineering, film, 3D animation and webpage design.

Measurement May Vary

Just how big a scene you can map using close range photogrammetry from ground-based images combined with cost effective tools may again depend upon what software you use. "It's a question of how big a scene can be mapped in one separate segment of a project," says Matt Klymson, director of sales for Eos Systems, referring to his company's PhotoModeler program. "The limit is created by the resolution of cameras," he continued. "A camera used by a law enforcement officer now with a range of 4 to 8 megapixels tends to simply run out of nicely usable resolution at a range of 150 feet."

Lee DeChant, president of DeChant Consulting Services, which sells the iWitness program, explains, "The iWitness

close-range photogrammetry program has the capability to 'stitch' multiple projects and account for the scene's axis tilt (the ground slope angle) when the scene is tens of meters in length. It is accurate in 3D to a few centimeters over very long distances, accomplished primarily from a consumer grade digital camera."

As law enforcement and department of transportation officials strive towards shorter road closures following an incident, Close-Range Photogrammetry is quickly gaining recognition as an easy-to-use, fast, and reliable method for mapping and measuring crash or crime scenes.

Numerous law enforcement agencies have proven close-range photogrammetry to be an accurate and viable measurement tool. To recap, close-range photogrammetry offers many benefits. Equipment requirements and costs are minimal, consisting primarily of a modestly priced consumer-grade digital camera, a photogrammetry software program, and a drawing program able to accept .DXF files to produce the 3-D diagram.

Photogrammetry is a simple process, whereby a police officer or reconstructionists: a) takes the proper digital images of the evidence at the scene; b) measures at least one known distance observed in three or more digital images at the scene for project scaling; c) imports the digital images into the photogrammetry software and marks them accordingly—(the software then automatically orients the camera in 3D space and processes the data to provide accurate 3D coordinates of the points and lines marked within the scene); d) imports the photogrammetry data into a CAD program to complete a diagram.

Photogrammetry can bring the jury back to the scene, where the technology provides us the ability to make new measurements of the scene's past by retrieving the archived digital images.

Close-Range Photogrammetry can be a boon to any traffic officer or reconstructionist who adopts it, whether the officer investigates only a few crash or crime scenes a year, or accomplishes a hundred of them. The photogrammetry technology combined with today's fast computer processing speed and quality digital cameras offers the right combination of elements

needed to investigate crash scenes with the least amount of time on scene. This ability translates to increased officer and motorist safety during the accident measurement tasks.

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