

Rhino Photogrammetry

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ABSTRACT

Rhino Photogrammetry is introduced, to minimize or eliminate the need for measurements at medium to small crime scenes, where it is critical to get in and out of the area as quickly as possible. The main benefit is the huge time savings based on eliminating the need to have every item of evidence measured twice by either baseline coordination or triangulation. Photogrammetry, or the technique for extrapolating accurate measurements from photographs, can be used to derive the same measurements as accurately as if measured with traditional tape measures. Using Rhino Photogrammetry would be optimal when bad weather is approaching and will destroy the evidence if left outdoors during storms or when the military needs to recover as much evidence as possible before becoming targets of enemy forces.

Keywords: Photogrammetry, Perspective Grid Photogrammetry, Rhino Photogrammetry, Crime Scene Diagramming, Computer Aided Design (CAD), Crime Scene Reconstruction, Forensic Science

Introduction

Rhino photogrammetry was developed in order to overcome two perceived negative aspects of the perspective grid photogrammetry technique. A brief overview of that technique is therefore necessary. The perspective grid photogrammetry technique is based on placing a perspective grid of some sort into an image or images of the crime scene, with the grid centered low and in the center of the composition. This can be done as an “insurance” shot, just to have in case a later need is realized, or when it is known that the time required for traditional tape measuring of the evidence is not available. This can be the case when stormy weather is

approaching, and high winds or heavy rainfall may affect the scene before traditional photographs and measurements can be made. It can also apply whenever there is the need for expediency, and gathering the evidence quickly is paramount.

Method: Perceived Shortcomings of the Perspective Grid Photogrammetry Technique

To use the Perspective Grid Photogrammetry method, a grid of known dimensions, frequently a set of four 1'x1' floor tiles laid together to form a 2'x2' square, is placed into the crime

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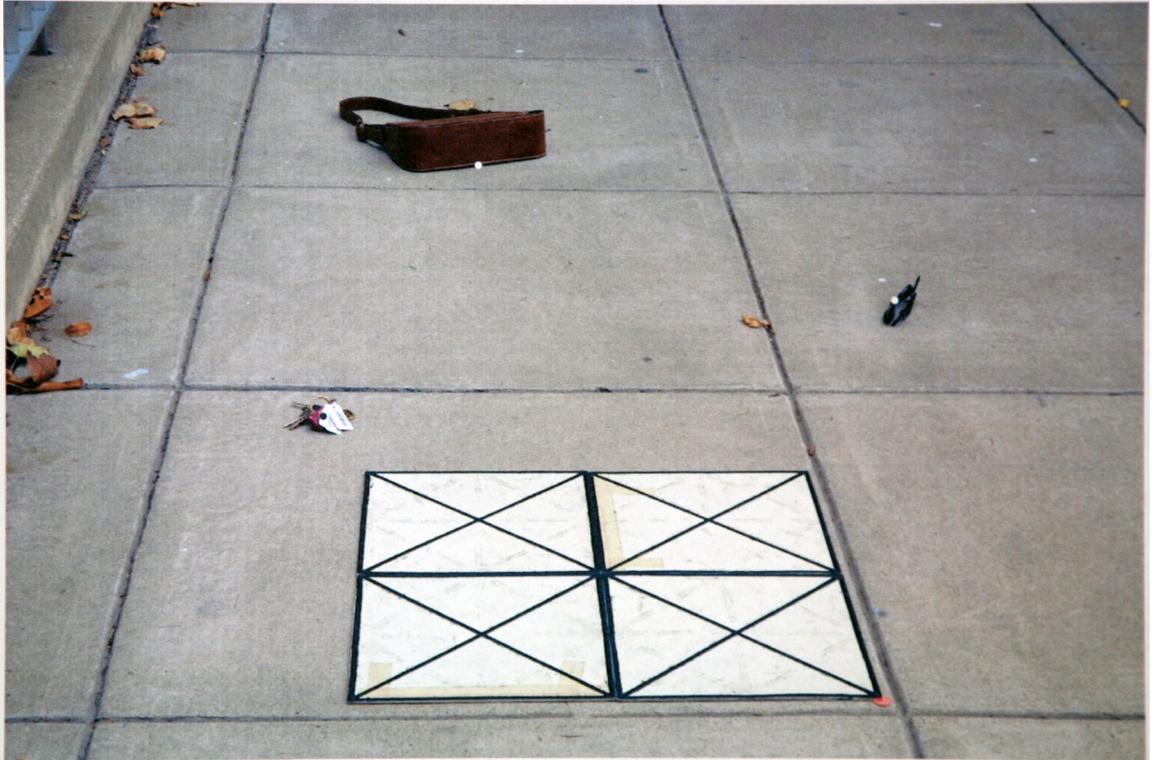


FIGURE 1 ►

scene, and photographed so that it is composed low in the field of view and centered. The grid is placed low in the field of view because at the bottom of the image the four sides of the grid are larger than when placed further back in the image, and the four sides of the grid will eventually be extended over the entire image. The larger each side of the grid is at the beginning of the process the more accurate all the later measurements, based on the grid, will be. The perspective grid is centered in the image so that extensions of the vertical sides of the grid will be close to perpendicular to the bottom edge of the photograph as possible. The later accuracy of the extended grid lines over the image is improved when the grid is centered. It should be mentioned that any rectangle can serve as the perspective grid. An officer's clipboard can be used as the perspective grid for lack of a more convenient rectangle. However, the larger the perspective grid, the easier it is to achieve accurate measurements. Figure 1 shows such a 2'x2' grid placed in a staged crime scene photograph [1].

The perspective grid now needs to have its four sides manually extended over the image in the areas where evidence is located. This process has been explained in a previous article in this journal [1]. But, here it is appropriate to point out that the extension of the four sides of the grid is done by extending the lines manually

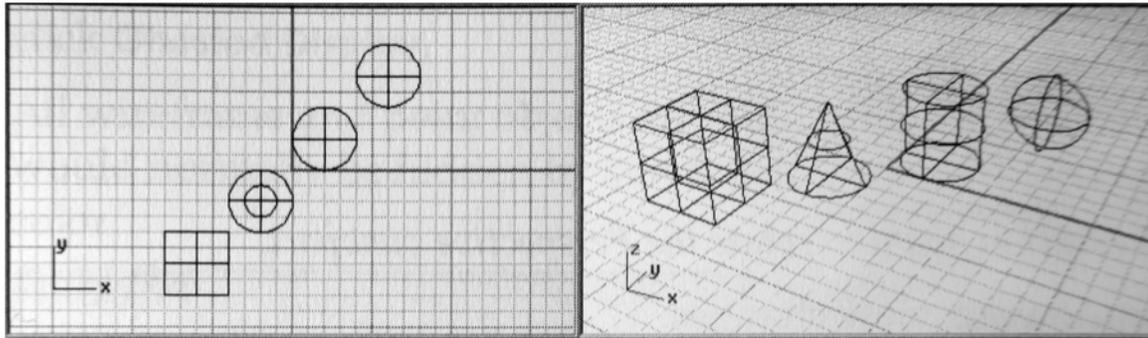
with a pen and straight edge. This is one source of potential error. If done carefully and with patience, this process can pinpoint the location of the evidence accurately. As accurately as can be determined with traditional triangulation and baseline coordination measuring techniques. In crime scene measuring classes at the George Washington University over the last five years, most students accurately determine the precise locations of the evidence using perspective grid photogrammetry. However, when the lines extended from the original grid are not extended with care, the answers derived can be off by several inches from the known dimensions of the evidence. Attempting to resolve this potential source of error, mistakes made when manually extending the sides of the grid over the image, was one motivation to find "a better way." Of course, there are other possible sources of error that be related to photographic imagery, such as the resolution of the image, lens distortions and distant evidence becoming progressively smaller and more difficult to see, but these issues are shared by most imaging systems, and both the perspective grid and the rhino photogrammetry techniques are equally affected by these.

A second challenge with the perspective grid photogrammetry technique is the need to have four 1'x1' floor tiles readily available. This may be easy when they can be stored conve-

niently in the trunk of a patrol car, but many crime scenes can be off the beaten path where carrying the grid in a backpack may not be feasible. Rhino photogrammetry does not require such a grid system be available.

er planes would require a new Rhino triangle on each plane be determined and aligned with that plane. This is not necessarily a shortcoming; it is a fact that has to be kept in mind.

As stated previously, Rhinoceros 3D is soft-



◀ FIGURE 2

Rhinoⁱ Photogrammetry: An Attempt to Resolve These Shortcomings

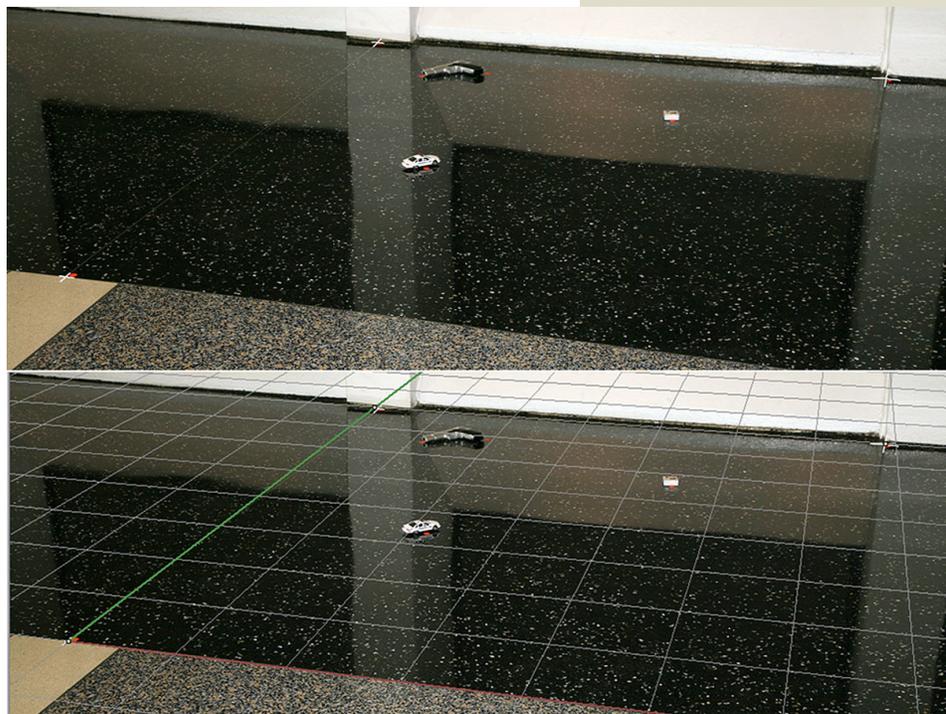
In an attempt to resolve the inaccuracies resulting from the manual extension of grid lines over the scene with a ruler and pen, the author began looking for computer software featuring an x-y coordinate system, also called a Cartesian Plane (CP). This CP system would then be superimposed over a crime scene photograph and locked, or aligned, to the plane the evidence is on. This is accomplished by locating a known triangle of three fixed features in the crime scene photograph, returning to the crime scene when it is convenient to measure this triangle, which the author calls the Rhino triangle, and then creating this triangle on the Rhino CP. The crime scene image is then imported into the Rhino software, and the CP with the Rhino triangle on it is aligned to the crime scene image so the CP triangle is superimposed with the same points in the crime scene image. This effectively locks the CP with the crime scene photograph, and Rhino software can now indicate the distance between any two points in the crime scene as if one were measuring the same distance with a tape measure.

One caveat must be mentioned. The CP will enable any evidence on the same plane as the Rhino triangle to be determined. The extrapolation of the measurements of evidence on oth-

ware principally used for 3D modeling. Figure 2 shows the CP with some elementary geometric shapes created in the software, seen from two points of view: from directly overhead and from a perspective view [2].

Figure 3 shows a mock crime scene set up before and after the Rhino 3D CP system has been superimposed over it. Pick any point in the lower crime scene image, and its distance to any other point in the crime scene can be determined by the Rhino 3D software [2]. Measure any item of evidence from two points and you've effectively triangulated the evidence, and can now put it into a scale diagram of the scene or export these measurements into an agency's CAD crime scene diagramming software.

▼ FIGURE 3



ⁱ The word "Rhino" is derived from a product called Rhinoceros 3D®, 3D modeling software by Robert McNeel & Associates, 3670 Woodland Park Ave N, Seattle, WA 98103 USA.



It should be mentioned that there are many software products featuring variations of CPs available. Rhino 3D is just one of them. However, it was the software selected by the author to enable this type of photogrammetry to be done, and for this reason, the author named this type of photogrammetry after this product, with the developer Robert McNeel's permission.

Perspective Grid Photogrammetry has been taught as part of the crime scene diagramming class at George Washington University's (GWU) Forensic Science Department since 2000. The author's use of Rhino 3D software, called Rhino Photogrammetry, has been taught at GWU since 2005. Scenes with known measurements are provided to students and, using both perspective grid photogrammetry and Rhino photogrammetry, they must determine the locations of the evidence within the photos. Most are able to extrapolate accurate measurements of the evidence on their first attempt using both techniques. Students, however, seem to prefer the Rhino photogrammetry system more because it does not require the user's artistic skills to accurately extend the original perspective grid over the crime scene image.

As good as Rhino Photogrammetry may seem, it is still dependant on having three fixed features of the scene relatively close to, and on the same plane as the evidence one wants to document. These three fixed features can be measured at the crime scene when the evidence is originally photographed, or when possible to return to the scene, with or without a warrant as the case may require, at a later time in order to measure the three fixed features. But, what if there are not three fixed features near the evidence? And, what if returning to the crime scene may not be possible?

A New Direction

The author is currently investigating a new technique that will overcome the need to measure any fixed features at the crime scene, by combining aspects of the perspective grid photogrammetry and the Rhino photogrammetry techniques. This newer method is being called 3-Point Photogrammetry. The genesis of this idea occurred after presenting workshops on both previous techniques at the Association of Crime Scene Reconstruction Educational

Conference in Jacksonville, Florida from February 8-10, 2011. After the conference, a member of the Naval Criminal Investigative Service (NCIS) asked if these photogrammetry techniques could be adapted for Special Agents working crime scenes in war zones where it is essential to get in and out of the scene before being targeted by hostile forces. This, perhaps, is the ultimate need for an accurate and quick method of compiling crime scene measurements.

Considering the possibilities for reducing the 2'x2' Perspective Grid so it could conveniently be carried in a soldier's gear pack, it was realized that a square perspective grid is not really necessary. It is just necessary to lock the Rhino CP to the crime scene, and all that is needed to do that is to use a triangle. To define a plane, all that is needed is three points. However, rather than having to find three fixed features within the crime scene, the only triangle necessary will be a triangle brought to the crime scene by the investigators.

Instead of a square or rectangle, a triangle will be placed into the crime scene, on the planes where evidence is located. However, is it not practical or necessary to create some sort of physical triangle to carry in the gear pack. It is not practical because initial experiments have shown that the larger the triangle, the more accurate the distances eventually extrapolated from it. Portable triangles are too small and cumbersome to have much value at any but the most confined scenes.

The essence of a triangle is its three points and the known distances between the three points. To be applied to photogrammetry, the triangle would need to be a right triangle, or one with a 90 angle. Two types of right triangles are currently being considered: a 3-4-5 right triangle and a right isosceles triangle.

Either of these known triangle shapes would enable a CP to be locked to the crime scene photo, after which all items of evidence, as well as all other fixed features of the crime scene, could be determined in relation to the known triangle. Once this new 3-point triangle is on the same plane as the evidence, it would be equivalent to the fixed features of the scene being known first, as was done with the original method of Rhino Photogrammetry. Since fixed features of the crime scene as well as the locations of every item of evidence within the



photo will now be able to be determined, an accurate crime scene diagram can be created, in scale. All of this should be possible from just a photo with a known triangle inserted into the scene before the photo is taken.

How would either of these triangles be easily constructed within a crime scene if carrying an actual physical triangle is considered a limiting factor? Two ideas are currently being considered. One is using two carpenter's measuring tapes, the kinds that are partially curved and naturally form a straight line. One can be set to 3'. This one forms a 3' segment running from left to right, centered and low in a crime scene composition. These two points need to be marked in some way, so that this tape measure can then be used for the 4' distance. In Figure 4 and Figure 5, Post-it notes were used with a dot in each center. Of course, a durable, weatherproof solution for marking the points of the triangle will ultimately have to be used.

Once the 3' baseline has been marked, the same tape measure can now be extended to 4' and positioned perpendicularly from either point on the baseline, as in Figure 4. With that tape measure left in place, a second tape measure is now set for 5', aligned with the first dot and the end of the 4' tape measure. This ensures the first tape measure is forming an accurate perpendicular with the baseline, a right angle.

Figure 5 shows the 3-4-5 right triangle with the tape measures removed. Now, the image can be recomposed to include more surface area so more evidence is imaged within the borders of the photograph. Try, however, to have the baseline of the triangle remain parallel to the bottom edge of your image. Initial studies have shown that having the CP aligned with one side parallel to the bottom side of the photograph makes the alignment of the CP to the image simpler.

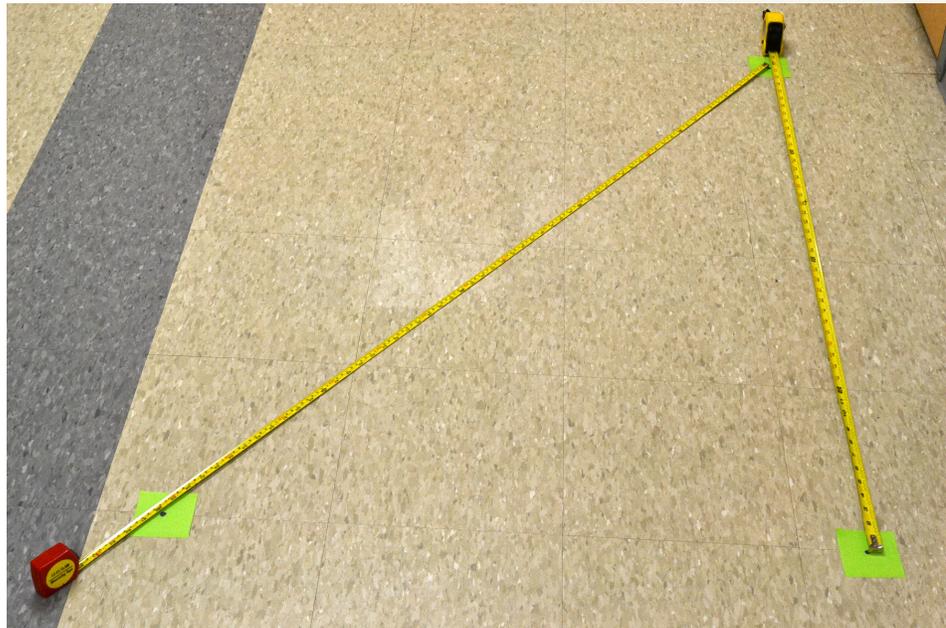
In addition to the two measuring tapes, we are also working with foldable foot-long scales which can quickly be unfolded to make 3' and 4' sides of a right angle.

Conclusion

Rhino photogrammetry does not require the use of total stations or laser-based measuring systems that can cost from \$20,000 to \$200,000. Those systems will still apply to very

large outdoor crime scenes when the weather is fair and time permits the set-up and calibration necessary for these systems. Other examples of software available to collect measurement data from crime and accident scenes include Photo

▼ FIGURE 4



▲ FIGURE 5

Modeler[®] and iWitness[™]. The costs of these products begin at \$1145 and \$995 respectively. Although considerably less expensive than the laser-based systems, above, they are still predominantly used at medium to large crime scenes. The photogrammetry methods mentioned here are specifically of use at smaller crime scenes when none of these techniques are likely to be used. Since most crime scenes are relatively small in size, Rhino photogram-



metry can now allow photogrammetry to be used in situations where it would not otherwise have been used. It also is designed to assist when the need to gather the evidence expeditiously is a necessity.

For those interested in Rhino photogrammetry, Rhino 3D provides a free evaluation download of their software (www.rhino3d.com). A written step-by-step tutorial and a video tutorial have been included with the supplemental material available on the ACSR website.

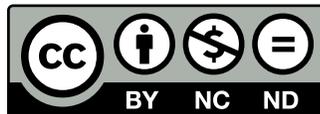
If interested, you may contact the author at erobinso@gwu.edu, or at 202-242-5767. This concept of 3-Point Photogrammetry has currently been submitted to NIJ as a grant proposal to validate the technique. We want to

determine the size of a crime scene that can effectively be worked with this method. There will come a point when the scene becomes large enough where Total Station type systems may be required.

References

[1] Flanagan J, Robinson E. Off the Grid: Perspective Grid Photogrammetry in Crime Scene Reconstruction. *J Assoc Crime Scene Reconstr.* 2011;17(4):57-61.

[2] Robinson EM. Crime Scene Photography. 2nd ed. Burlington (MA): Academic Press; 2010.



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