COMPUTER VISUALIZATIONS OF TRAFFIC ACCIDENTS USING PHOTOGRAMMETRY

By T. K. Koo

ABSTRACT: This paper documents the results of various experiments in the use of non-metric close-range photogrammetry for traffic accident mapping. Photographs from amateur cameras were geometrically restituded by desk-top PCs for generating three dimensional wire-framed and shaded models of traffic accident scenes.

INTRODUCTION

The use of close-range photogrammetry for documenting traffic accidents is well established in parts of Europe and Japan. One of the first countries to systematically use photogrammetry for traffic accident mapping is Switzerland where the first traffic plans were produced in 1933. Subsequently, in 1935 Germany followed suit. Today photogrammetry is an accepted practice in most parts of Europe. However, few countries have embraced this technique with as much enthusiasm as Japan (Ghosh, 1980). It was noted by Ghosh (1980) that "there is no road accident related court case pending anywhere in Japan beyond one week after the accident."

But elsewhere in the world, there is, unfortunately, very much less enthusiasm for using photogrammetry for documenting traffic accidents. Commonwealth countries like Singapore which has inherited the English laws do not normally accept traffic plans generated from photographs as admissible evidence in courts. For this reason, research into photogrammetry for traffic accident mapping is mostly carried out in non-English speaking countries.

Instrumentation for traffic accident mapping

Traffic accident maps in these countries are traditionally compiled from photographs taken with stereometric cameras and restituted from special analogue plotters. An excellent review of the instrumentation available for traffic accident mapping is given by Atkinson (1988).

In recent years, non-metric (meaning off-the-shelf) and semi-metric cameras (like the Rolleiflex 6006 system) have been preferred, and analogue plotters are usually being upgraded to, or else being replaced altogether by, analytical plotters

But the use of expensive analytical plotters for traffic accident mapping may not be cost effective because the accuracy demands for traffic accident maps are not exacting. Hence, since the beginning of the late 80s, traffic accident mappers have turned to small format, low cost, analytical systems (like the Adams system) and 2-dimensional cartographic digitizes (eg the Rolleimetric).

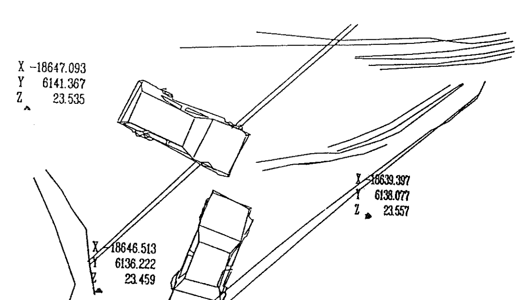

FIG. 1. A typical traffic accident plan prepared from close-range photogrammetry (original scale 1:100).

Photogrammetry and Visualisation

The traditional output of photogrammetry is a 2-dimensional plan. While this is adequate for topographic mapping, it is definitely insufficient for non-topographic mapping. Findings from cartographic research suggest that many non-mappers have problems perceiving 3-dimensional objects in 2-dimensional planes. A typical two dimensional plan of a traffic accident survey is shown in figure 1.

In traffic accident mapping, for example, the users of plans are usually lawyers and judges, professionals who are more at home with words than contours. They might not be totally comfortable with the idea of interpreting 2-dimensional plans. Hence, it is not just desirable, more logical to marry photogrammetry with computer visualisation so that the captured 3-dimensional accident scene can be displayed in a "3-dimensional" world.

Apart from the ease and clarity with which visualization systems convey ideas and messages to involved persons (such as judges and traffic policemen), there is one more compelling reason as to why it is in fact sometimes necessary to employ visualization systems for traffic accident mapping. Because of the limitations imposed by metric photography, there is an increasing trend in traffic accident mapping to use convergent non-metric photographs for data acquisition (see Waldus and Kager, 1984).

But convergent photographs do not make for good stereoscopic models. Hence the construction of traffic accident scenes must be done analytically. A 3-dimensional visualization system must, therefore, work in cooperation with analytical photogrammetry for displaying the restituted 3D traffic accident model.

The PMCAD II system

The PMCAD II system represents one successful attempt at developing a low-cost photogrammetric-based visualization system for traffic accident mapping. The acronym PMCAD stands for Photogrammetric Mapping through Computer Aided Drafting. A detailed description of PMCAD II can be found in Koo and Aw (1991). Here only the gist of the paper is presented.

PMCAD II is a refinement on PMCAD (Koo, 1989) in that it allows shaded renderings of the traffic accident scene. The system was designed for use by non-photogrammetrists. Using off-the-shelf cameras, PMCAD II is able to reconstruct traffic accident scenes in a microCAD system from "random" pictures taken of the accident scene. Although PMCAD was originally conceived for traffic accident mapping, the resultant system is also eminently suited for the re-creation of any wire-frame or pseudo-solid (shaded) model from 2D imagery.

The concept of PMCAD II is illustrated in figure 2. Essentially, the system marries analytical photogrammetry with microCAD (microComputer-Aided-Design). Two software bridges, a pre-processor suite and a post-processor suite, work in cooperation with the Direct Linear Transformation (DLT) of Karara and Abdel-Aziz (1974) to build up the solid model piecewise from 2D images obtained from enlarged non-metric photographs.

Control points for the DLT solution

To solve for the DLT parameters, the photo and object space coordinates of at least six well distributed homologous points must be known. PMCAD solves the problem by placing four calibrated range poles arranged 90^{o} apart on the circumference of a prescribed ring within which the debris are to be mapped, see figure 3. The co-ordinates of the four points on which the calibrated poles rest are surveyed on an arbitrary coordinate system and only after the accident debris has been cleared. This will ensure that traffic flow will not be held up unnecessarily.

The described arrangement of calibrated range poles will give rise to an "array" (more than the required number) of six control points. Every identifiable point on the range pole can serve as one control point. The plan coordinates of each point on the range point (X,Y) is the same. Only the height dimension (Z) changes. And since the pole is calibrated, each point's (X,Y,Z) is easy identifiable.

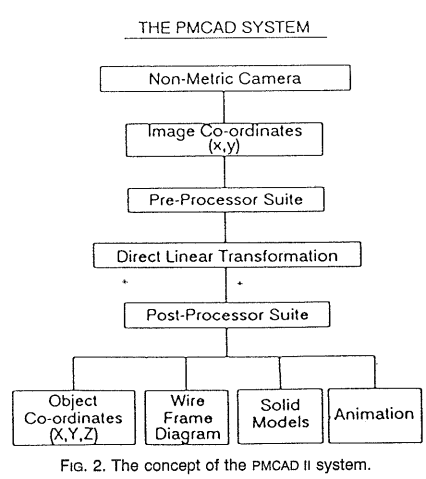

FIG. 2. The concept of the PMCAD II system.

Two simple rules are also prescribed for the photographer. Rule A : frame the picture using the zoom lens so that the picture captures the calibrated poles in three positions: left hand edge, middle, and right hand edge. Rule B : the base-distance ration should be about 1/5. An example of a picture which complies with the two rules is shown in figure 4 .

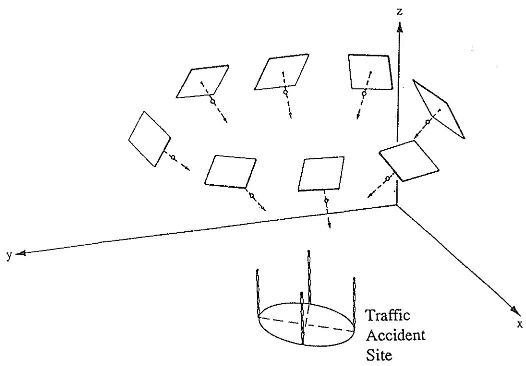

FIG. 3. Suggested arrangements of "minimum" control point configuration.

FIG. 4. A photograph of a simulated accident site taken with a non-metric 35- to 70-mm zoom camera, showing "preferred" range pole arrangement.

Pre- and Post-processing

After the pictures have been taken, the first step is to extract, analyse and format image coordinates (x,y) on-line from the non-metric photographs for the DLT solution. A low-cost commercially available digitizer A3-sized (420mm by 300 mm) digitizer was used for PMCAD II. Four postcard-sized pictures of the accident scene can be arranged for simultaneous digitizing on the A3-sized digitizer, see figure 5. The extracted (x,y) photo coordinates are now sent into the DLT suite for the solution of the object space coordinates (X,Y,Z).

After the DLT suite has been run, the output file of the digitized object space coordinates become available. This X,Y,Z file now forms the basis for re-creating the three dimensional computer model. In the PMCAD II solution, the 3D computer

FIG. 5. Enlarged positives arranged on the digitizer for on-line data (x,y) acquisition.

model is re-created inside a microCAD system. This approach of marrying microCAD with analytical photogrammetry has the important advantage of eliminating the tedium of writing graphic entities - lines, text, symbols, points, splines, 3D faces, 3D line, 3D splines - which together make up the 3D model.

The post-processor suite is PMCAD's visualization tool. It is here that the component entities of the solid model are put together. The post-processor suite guides the user into building up the solid model using simple and umambiguous instructions. The resultant accident scene is either a wireframe object (figure 6) or a shaded rendering of the same (figure 7).

Conclusion

The availability of low-cost, small format, non-metric close range photogrammetry coupled with computer visualisation techniques has convinced many of the exciting prospects of using this technique for traffic accident mapping.

Inspite of the legal impediments to accepting traffic accident plans from photogrammetry, the Singapore Traffic Police is exploring its possible use. The project while still in its very embryonic stage is both exciting and challenging.

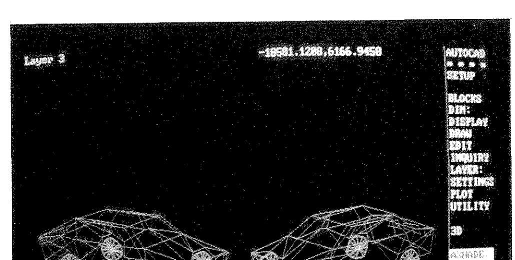

FIG. 6. Wire-framed diagram generated by PMCAD II of the simulated accident scene.

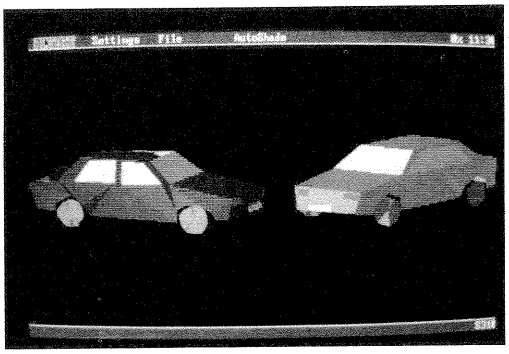

FIG. 7. Shaded rendering of Figure 6.

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