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Mapping Street Intersections Using Close-Range Photogrammetry*

The method is accurate and operationally effective.

Abstract: *A joint project using close-range photogrammetry to map street intersections has been conducted this past year by the Dade County Traffic and Signalization Department and the Civil Engineering Department of the Miami-Dade Community College. The project was designed to determine the feasability of using this science to map urban street intersections and to use the base maps produced for future signalization and traffic design projects. Using part time students employed by the traffic department a procedure was developed which is operationally effective, and the resulting maps plotted by the students have met all the traffic and transportation department accuracy standards.*

Introduction

The need to quickly map an intersection is one of the most pressing and current problems facing traffic design agencies throughout the United States. The growth of urban areas, the increased vehicular traffic, and the changing needs of the community has tremendously increased the work load on the traffic design departments. To upgrade an intersection or install new traffic signals, a base map showing the existing configurations of the site must first be prepared. Any new technique which would have cost-and-time benefits in the preparation of these base maps would be of importance to a traffic design department.

A joint project of photogrammetrically mapping street intersections has been conducted this past year by the Dade County Traffic and Signalization Department and the Civil Engineering Department of the Miami-Dade Community College. The project was designed to determine the feasability of using this science to map urban street intersections.

General Mapping Procedure

The following mapping procedure has been found to be operationally efficient and effective.

The field equipment, except the camera and film could be stored permanently on a truck. The vehicle used was a pickup truck with heavy duty springs to minimize rocking and an elevated flashing signal light. Originally the camera was set on the ground at different points on the site, i.e., center of intersection, sidewalks and different offsets. However, it was found that the mobility of having the camera mounted on the truck was advantageous, and the camera position indicated in the procedure fulfills the mapping strategy (Figure 1).

The equipment used on the project consisted of the following:

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(a) Sterometric Camera and Tripod
(b) Triangle For Tripod
(c) Film Plates
(d) Ten Cones
(e) Ten Targets
(f) Keel, Flagging, Caulk
(g) Two Tapes
(h) Note Book
(i) Light Meter
(j) Three Range Poles
(k) Portable Tape Recorder
(l) Philadelphia Rod

Upon arriving at the intersection the truck is parked and a visual examination is made to determine the general mapping procedure.

(1.) Determinations are made concerning the position of the truck (generally in line with the greatest widths).
(2.) The important features that must be mapped are determined.
(3.) Hidden manholes, obscure curb lines are identified and targeted (not measured).
(4.) The positions of the sun might have an influence on the camera position.
(5.) The sequence of operations, taking the models is agreed upon.

Once the sequence of operations is determined, the truck is moved into position (Figure 2). This is the general position occupied. The back of the pickup truck faces the models. The driver of the truck also serves as the camera operator. He is responsible for setting up the camera and for taking of photographs.

FIG. 1. Stereometric camera mounted on a pickup truck.

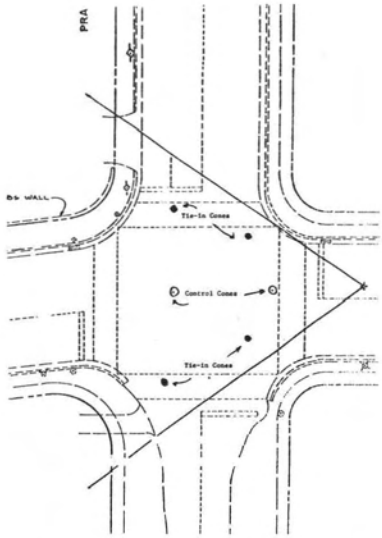

FIG. 2. First set of photograms.

The field men meanwhile set up the control and target all the points that need to be identified and mapped.

TAKING THE PHOTOGRAPHS

In order to eliminate the possibility of the tripod legs slipping in the truck, a triangle is used.

(1.) The tripod is erected on the triangle and leveled.
(2.) Next, the camera is put on the tripod.
(3.) Then, the electrical connections are made by connecting the battery to the camera (care is needed to avoid reversing the polarity to the camera).
(4.) The camera is checked in order to assure that the shutters are operating.
(5.) The correct lens aperture and shutter speed are set.
(6.) The correct numbering of the plates is then set in the camera.

A redundant set of pictures is taken for each model. To avoid mixing of the plates and for added control in the developing stage, two separate film cases are used. (We have found from experience that the use of two separate film cases is advantageous.)

The camera height on the tripod in the truck is not further elevated because additional height has not proved to be of any advantage.

During camera setup the field group targets the first model. The targeting includes:

(a) Control points, two cones 40 ft. apart and 35-37 ft. from camera.
(b) Tie-in points at both sides of the model.

(c) A surveying rod is placed in the model for vertical control. (A redundant check.)
(d) Targeting the important points needed to be mapped (curves, sidewalks, catch basins, stop bars, any breaks in the right of way, hidden electrical boxes, etc.).

CONTROL POINTS

The primary control is two cones running approximately normal to the base of cameras. The first cone is approximately 35 feet from the camera. This distance has to do with the base setting in the plotter. The control distance between the cones always is maintained at 40 feet as a standard. These points are marked with keel on the pavement to insure their position since there is a possibility of a vehicle hitting the cone. These control points are also the tie-in points for the second set of models when directions are switched to map the other side of the intersection.

On both sides of the first model, the tie-in cones are placed. Their ground positions are also marked with keel. They are placed by the direction of the camera operator since he can (by looking through the view finder) see the side limits of the model (Figure 2.). These cones on each side of the central model are the tie-in controls for the adjoining models.

It is absolutely essential that the camera be level when the photographs are taken. If the camera is not level at the time of exposure, we advise the students to expose the plates, not even develop them.

The first set of photographs is taken. The redundant set from the separate case is also taken. The camera is swung to the right. The tie-in cones are seen on the left side in the new model.

Points of interest are targeted by the field crew. Sometimes a set of control cones is put in, generally not. Once the camera is level the two sets of photographs are shot again (Figure 3).

The camera is swung for the left model. The tie-in cones from the center model are on the right side of this model and the same procedure is followed. (Figure 4). It is important to remember that before the photographs are taken all the points that need to be targeted are identified.

Once this side of the intersection is completed:

(a) The camera is disconnected from the battery and put in the case. (It is too dangerous to move the truck with the camera on the tripod.)

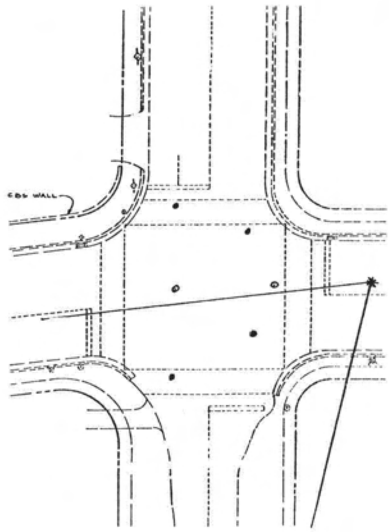

FIG. 3. Second set of photograms.

(b) The truck is moved to the other side of the road (Figure 5).
(c) The original control cones are now the tie-in targets connecting the two sides of the intersection.
(d) Generally two new control points are also needed (normal to the camera base). However, there have been cases in small intersections where the original control points were used.
(e) The procedure is now repeated on this side. (Figure 5, Figure 7). The photographic coverage from one side is shown in Figure 8, the total coverage in Figure 9.

Two men can handle the job adequately, but

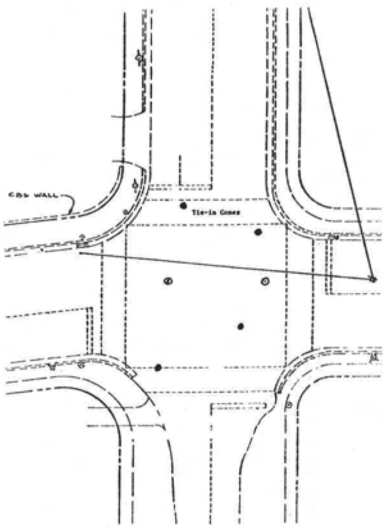

FIG. 4. Third set of photograms.

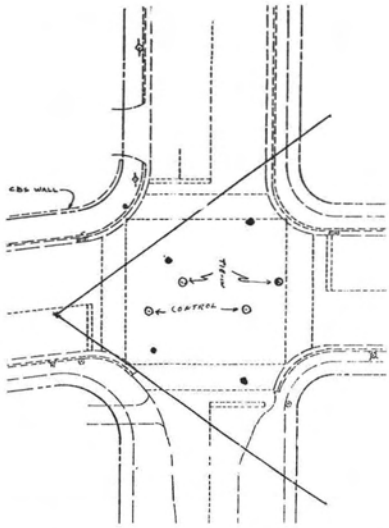

FIG. 5. Fourth set of photograms.

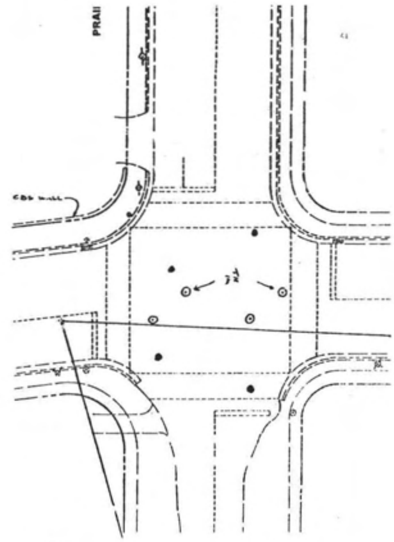

FIG. 7. Sixth set of photograms.

with a three-man crew the entire procedure can be simplified and speeded up.

Before leaving the intersection, one of the field men dictates into a portable tape recorder all his observations concerning the condition of the intersection, relating to the electric lines, transformer assemblies, stop bars, poles, sidewalks, curbs, needed repairs, all the information that can be used for evaluation. A typewritten transcript is made as a supplemental report.

PLOTTING PROCEDURE

The following step-by-step plotting procedure is followed:

(1.) Set the focal length.

(2.) Set the base. The SMK 120 camera has a base of 1200 mm. Since the desired model scale was 1/120 a base model setting of 10mm was used.

$$bx = \frac{\text{base of camera}}{\text{Model Scale Number}}$$

(3.) The plotter is leveled at the start of each day. If there is any doubt that the controls were touched a grid plate is used to put Kappa, Phi, and Omega at zero.

(4.) Before beginning a new intersection a check is made of the plotter (object space)

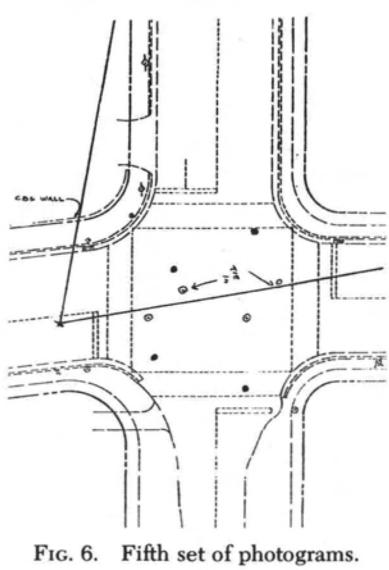

FIG. 6. Fifth set of photograms.

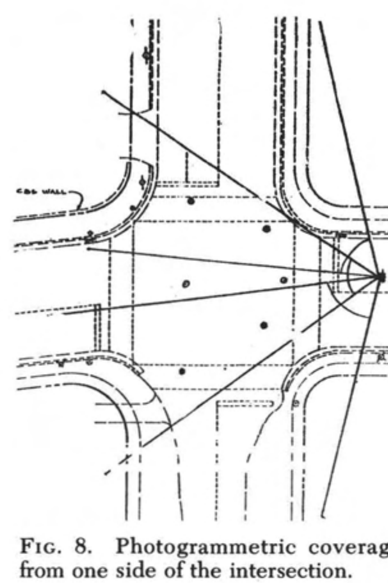

FIG. 8. Photogrammetric coverage from one side of the intersection.

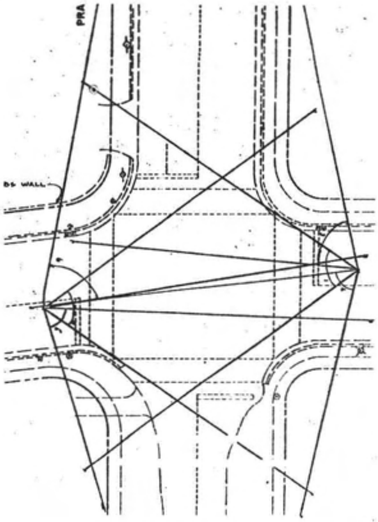

Fig. 9. Total photogrammetric coverage.

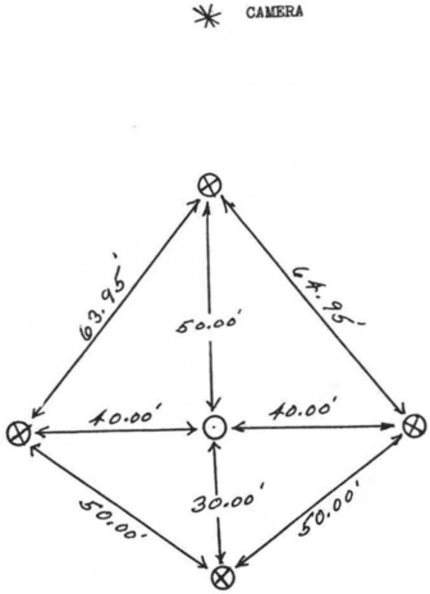

Fig. 10. Layout of the control field.

with a control field (Figures 10 and 11). The time required to check is approximately 30 minutes. The plotting scale in which the control field is checked is 1 inch = 10 feet. The model scale remains the same 1/120. The two adjustment controls used in Phi2, bz2.

(5.) The negative diapositives of the first center model are inserted first. Correct centering of the diapositives is extremely important.

(6.) This center model (Figure 2) with the control points is plotted first at a scale of 1 inch = 20 ft. The floating dot is set to the top lip of the cone.

(7.) If the control cones in the model do not plot to 40 ft. a slight adjustment with Phi 2 is all that is needed.

(8.) Generally, plot only the targeted points and draw tne map by connecting the relevant targets.

(9.) Plot the left model next, utilizing the tie-in control cones (slight adjustment with Phi 2 if necessary). Shift the plotting paper to meet the points.

(10.) Plot the right model. Again shift the paper on the plotting table to coincide with the tie-in cones and the plotted points.

(11.) Plot the center model from the other side of the intersection. The original control points will tie together both sides of the intersection.

(12.) Plot the left model.

(13.) Plot the right model.

If a model fails to fit after even with a slight adjustment of Phi 2, check the centering in the plate holders. If the centering is good then the camera was probably not level at the time of exposure (try the redundant

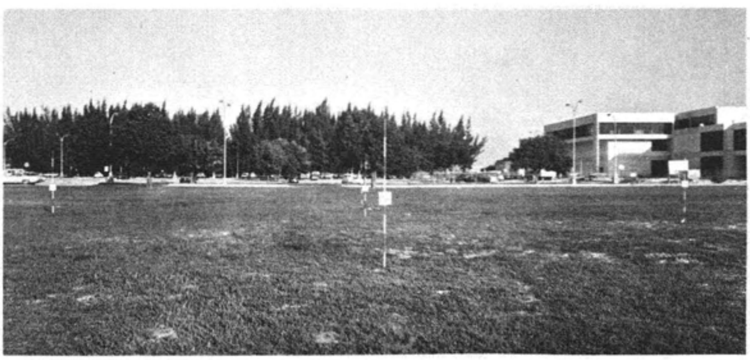

Fig. 11. The control field.

TABLE 1. MODEL SCALE/DEPTH-OF-FIELD/INSTRUMENT SETTING TOPOCART.

Model Scale		Base mm	Z min. ft	Z max. ft	Depth of Field ft	Gears 1″/10 ft	Gears 1″/20 ft	Height gears for model scale
$\frac{1}{24}$	$\frac{1\text{ in.}}{2\text{ ft}}$	50	7	24	17	52 26 80 40		127,50 48,8
$\frac{1}{38.4}$	$\frac{1\text{ in.}}{3.2\text{ ft}}$	31.2	11	38	27	39 39 100 32	52 26 100 32	99,78 65,104
$\frac{1}{48}$	$\frac{1\text{ in}}{4\text{ ft}}$	25	13	48	35	39 39 85 34	52 26 104 65	99,78 34,85
$\frac{1}{60}$	$\frac{1\text{ in.}}{5\text{ ft}}$	20	16	60	44	39 39 80 40	52 26 104 65	99,78 34,85
$\frac{1}{120}$	$\frac{1\text{ in.}}{10\text{ ft}}$	10	32	120	88	52 26 40 80	39 39 80 40	66,130 40,80
$\frac{1}{150}$	$\frac{1\text{ in.}}{12.5\text{ ft}}$	8	40	150	110	52 26 34 85	39 39 104 65	66,130 34,85

model). Additional plotting coverage can be attained by changing the plotter base and inserting the appropriate gears. (Table 1).

RESULTS

At the Miami-Dade Community College in this project using beginning students, 15 different intersections were successfully mapped. Figures 12, 13, and 14 are examples of several of those intersections.

DATA

Accuracy: At the plotting scale of 1 inch = 20 ft. with a good set of models we were

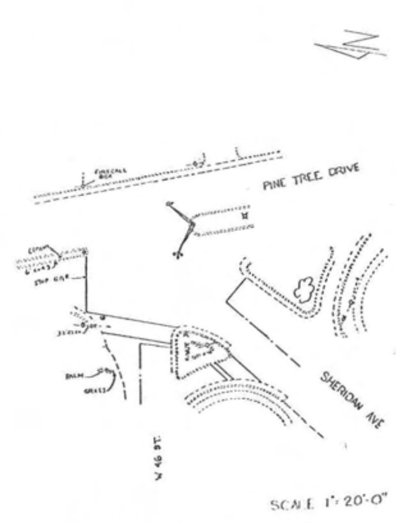

FIG. 12. Computer map.

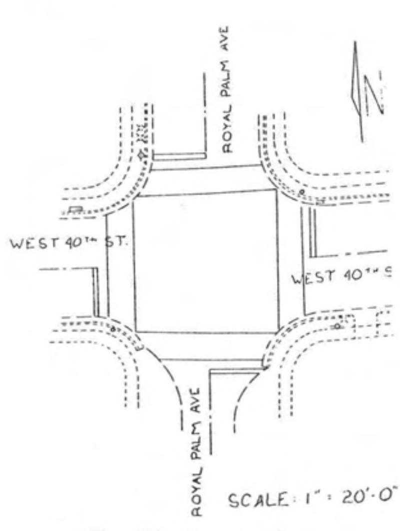

FIG. 13. Intersection.

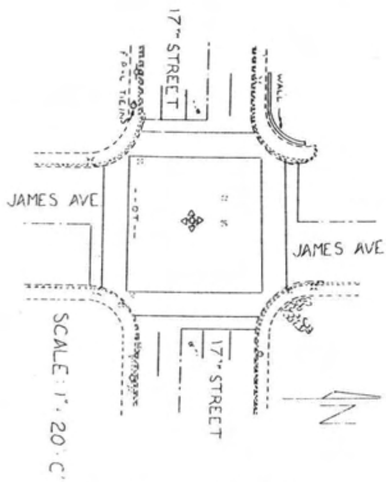

FIG. 14. Intersection.

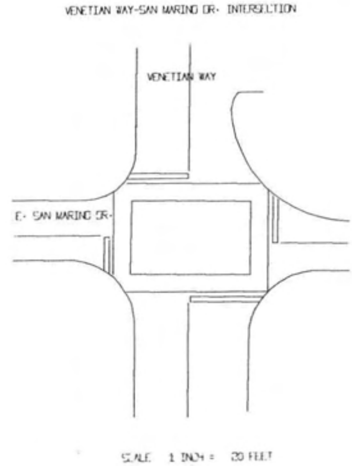

FIG. 15. Intersection.

always within 6 inches (0.63 mm at plotting scale) of all points.

(a) The time required to do a site is estimated as:

1. Simple intersection
   (Field Mapping)
   one hour ± ½ hour ....2 men
2. Involved intersection
   (Field Mapping)
   two hours ± ½ hour ....2 men

b) Plotting time
   2-3 hours ....1 man

Advantages

(1.) One of the principal advantages of this technique is the ability to photogrammetrically map a single site when needed.

(2.) The model scale used was 1 inch = 10 feet. This is a larger model scale than normally used in large-scale urban and highway mapping. This large scale allows us to evaluate closely such difficult points as back of curb lines, the relationships of the height of power lines to telephone wires, and other important unique considerations which are identified at each site.

(3.) Plan and elevation maps can be drawn readily.

(4.) No airplane is needed, just a pickup truck.

(5.) A wide variety of scales can be utilized. We plotted directly 1 inch = 20 feet.

(6.) All the information seen within the area is from a horizontal perspective and can be mapped.

(7.) A data bank can be established for future reference. (These plans can be drawn anytime, redrawn, or stored for future drawing.)

(8.) Stero pictures can be made for office evalunalization and the use of close-range

(9.) Traffic does not have to be stopped to do the job (just a break in traffic).

(10.) The accuracy is high because of presignalization and the use of close-range photography.

(11.) The height and slope of poles, height of electric lines, etc., are easy to evaluate.

(12.) The information can be digetized and a computer-drawn map produced (Figure 15).

Conclusion

The dimensions of the intersections mapped in this project have been checked, and have met the accuracy standards of the Dade County Traffic and Transportation Department. Their preliminary cost analysis was favorable, and they have indicated their interest in further investigation and perhaps adoption of this system into their department activities.

Errata

Herbert W. Stoughton's name was incorrectly spelled in the "Memo from the President," which appeared in the June 1976 issue of this Journal.