THE KERN DIGITAL STEREO CORRELATOR IN CLOSE-RANGE APPLICATIONS

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ABSTRACT

The Kern correlator has been applied in close-range photogrammetry. Artificial texture was used and projected on the object at the time of photography. The accuracy was evaluated from a grid of 700 checkpoints. A considerable improvement in accuracy has beeen obtained compared to an earlier test.

1. INTRODUCTION

In a first test (Almroth and Hendriks, 1987) the Kern correlator installed on a DSR11 was applied in close-range photogrammetry. The effects of emulsion type, reflections and random patterns of different sizes were investigated.

For the measurements a set of 700 checkpoints measured in a 3-D coordinate measuring machine were available. The internal precision of the measurements were good but when compared with the check points there was a systematic error. In connection with further development of the calibration procedures for the solid-state sensor array cameras used in the system a shift in the x-coordinate due to the hardware set up was found. Since this could explain the systematic error found in the first test a second test were made with a change in the hardware configuration.

2. EXPERIMENTAL DESIGN

In the original test (Almroth and Hendriks, 1987) a set of stereo pairs taken with a Hasseblad MK-70 camera were used. The camera was calibrated for the distance used (1.5 m). The test object, a car door, is approximately one by one meter. An overlap of 60 % gave a base to height ratio of 0.25 in a normal case model. Two emulsions, Kodak Tri-X Pan and Kodak Plus-X Pan, were used. Computer generated random dot patterns with four different size of the elementary cell of the pattern were projected on the object at the time of photography.

34 regularly distributed points were marked as control points. The coordinates of those points were measured in a 3-D coordinate measuring machine (Leitz pmm 121010). In addition a grid of 700 checkpoints on the object, defined in the system of

the Leitz machine, were also measured.

The checkpoint grid was then measured with the correlator and by operator and the results evaluated using the meaurements in the Leitz machine. The accuracy was computed as the RMS of the differences between the mesaurements in the DSR11 and the ground truth. The internal precision was estimated from replicated measurements.

For the second test one of the stereo pairs used originally was chosen. In the remeasurement optimal parameters for the correlation were chosen (Hendriks, 1988) based on the results from the first test. The automatic gain control of the solid-state cameras causing the coordinate shift was turned off and modified solid-state camera calibration procdures (Almroth, 1987) were used.

3. RESULTS

The influences of film type, pattern size, reflections and choice of parameters for the correlator are discussed in two papers (Almroth and Hendriks, 1987 and Hendriks, 1988). Here the presentation is focused on the improvement in accuracy obtained by the minor change in the hardware and by improved calibration procedures.

In the first test it was possible to find optimal settings of the run-time parameters for the correlator. For the pixel size used in the system, 13 by 16 um, there was no significant difference between the two film types used. A pattern with a 150 um size of the elementary cell was optimal. The influence of reflections were tested by treating the surface with mat paint before taking some of the photographs. The result was a decrease in the RMS of 20 to 30 %. With the pattern used, the correlation was sucessful in more than 90 % of the points for all models measured.

Measured by	Gain control	RMS (mm)	Bias (mm)
correlator	on	2.200 - 3.306	-1.605 - -3.088
correlator	off	0.072 - 0.095	0.022 - 0.036
operator	-	0.414 - 0.475	-0.032 - -0.039

Table 1. RMS when compared to the checkpoints. Automatic gain control of the solid-state cameras on and off. RMS for same model measured by operator for comparison.

In the first test it was evident that a systematic error was present. The RMS and the computed bias (mean of differences) was of the same order. The correlator mesurements were consistent in sense that the measured value was always above the true surface. In table 1. the intervals obtained for the RMS and the bias with and without automatic gain control are shown as well as the corresponding values for measurements by operator.

4. DISCUSSION

In the first test measurements were made in the object system as defined by the 3-D machine but also in the model system. The systematic deviations in the object system were analyzed and compared to the measurements in the model system (Almroth and Hendriks, 1987). From the scale factor and the precision of the measurements in the model system the conclusion was drawn, that if the systematic trend could be removed, it was possible to obtain a RMS of at least 0.2 mm. The second test has verified this.

The resulting RMS is about 50% better than predicted from the first test. In addition it also smaller than the RMS from operator measurements. All the error sources (orientations, accuracy of control and checkpoints) are the same except the pointing precision of the parallax measurement. The relation between the second set of correlator measurements and the operator measurements can be explained by this fact.

If the precision of the parallax measurement is 5 um with a base to height ratio of 0.25 we would expect a precision in height in around 0.5 mm. This is verified by the operator measurements that range from 0.414 to 0.475. With a texture well suited for correlation like the random pattern used and an unfavorable model geometry the "pointing" of the correlator is superior to the operator. The results indicate a precision in the parallax mesurement of 1 um. This can be compared to the precison of a measurement of a single point with the correlator that was estimated to 0.5 um for a well defined target (Almroth, 1987).

5. CONCLUSIONS

The Kern correlator has been sucessfully applied to close-range imagery. Improvements in the hardware and the calibration procedures for the solid-state cameras in the system made it possible to obtain an absolute accuracy better than one to five thousand. The test indicates that it possible not only to successfully automate the measuring procedures but also to improve the accuracy by introducing correlations techniques.

6. REFERENCES

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