# AUTOMATED THREE DIMENSIONAL MEASUREMENT USING STEREO CCD CAMERA IN THE APPLICATION TO CLOSE RANGE PHOTOGRAMMETRY

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## ABSTRACT

A stereo CCD camera system with a linear array elements of 2048 has been developed for close range photogrammetry by the authors.

Digital image data of stereo mode are transfered to a Japanese micro-computer to permit an image matching line by line. A special pattern recognition technique has been developed to improve the accuracy and reliability.

A near real time photogrammetry would be carried out by this sytem if a speed up function will be introduced to the micro-computer.

Two examples of test measurement showed a possibility to establish an automated three dimensional measurement system.

## INTRODUCTION

A stereo CCD camera enables " a digital and real time close range photogrammetry ", if the pattern recognition to identify the conjugate stereo point could be speeded up with high accuracy.

In the past, an image correlation technique, for example,to maximize the correlation coefficient in the n x n pixels window has been utilized.

However, due to acutual troublesome features such as shadow or oclusion effects, the image correlation technique is not reliable for its stereo matching.

The biggest headache is not to be able to to detect whether a determined conjugate point is true or false.

In this study, illuminated grids with an assigned address of 8 bit M series optical patterns are projected at high speed on the object to be measured. Therefore, pattern recognition is only to identify the corresponding address of the conjugate point, which can reject any error of mismatching.

The second biggest headache is how to correct those errors resulted from misalignment of linear array, lens distortion and so on. In this study, only self calibration for correcting lens distortion was performed although calibration for other factors is being studied further.

## STEREO CCD CAMERA

Two CCD camera with 2048 linear array elements are moved by Motor 1 in the Y direction as shown in Figure 1. Two arrays are located to generate an epipolar plane for three dimensional measurement of a given section of the object. Pulse pattern generator of 8 bit M series drived by Motor 2 will provide with address number to respective stereo image points.

| | |
|---|---|
| Linear CCD array: | 2048 elements (14 um interval) |
| | TCD 102 C-1 (made by Toshiba) |
| Focal length of lens: | 28 mm |
| Base length: | 300 mm (movable) |
| Maximum size of object: | 500 mm wide and 300 mm high |

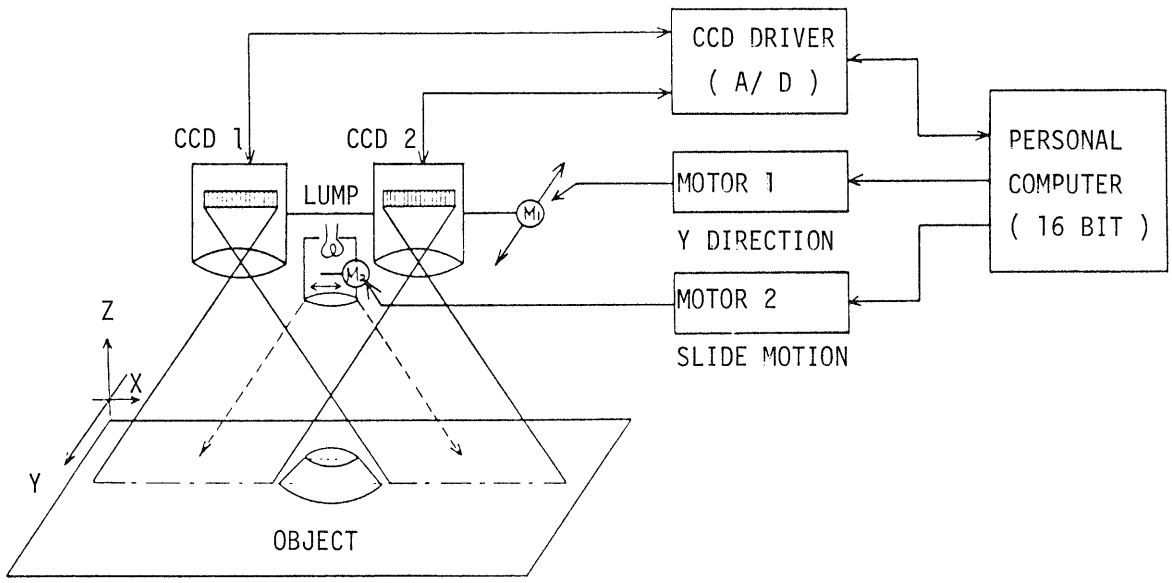



**Figure 1 Stereo CCD Camera for Close Range Photogrammetry**

## AUTOMATED THREE DIMENSIONAL MEASUREMENT

Step 1: Move the stereo CCD cameras to a certain position to be measured.

Step 2: Generate illuminated grids with 8 bits M series pulse patterns to give address number to each grid.

Step 3: Detect a peak of each grid as shown in Figure 2.

Step 4: Determine a conjugate point by checking the address number.

Step 5: Compute X and Z as follows;

$$X = x\ B/\ (\ x\ -\ x\ )$$

$$Z = f\ B/\ (\ x\ -\ x\ )$$

where B: base length

Step 6: Correct the lens distortion

Step 7: Plot the section or contour.

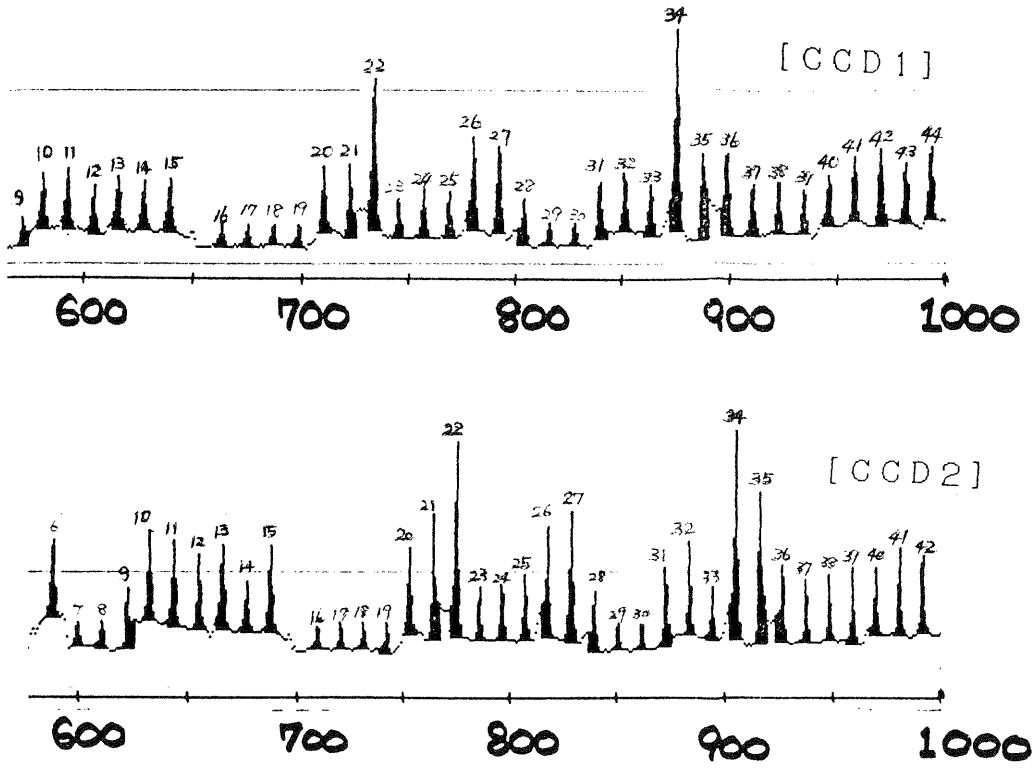



**Figure 2 Detection of Peak Signals**

## TEST MEASUREMENT

Test 1 Cone

Figure 3(a) shows computer generated sections of a cone without correction for lens distortion, while Figure 3(b) shows corrected sections. Height of the cone is about 30 cm. Average error of height was 0.4 mm while the maximum error was 0.78 mm. Required time including data aquisition with auto gain control, peak detection, stereo matching and drawing was 20 minutes to draw 45 sections.

Test 2 Sculptured face

Figure 4(a) shows computer generated contour map with the interval of 5 mm, while Figure 4(b) shows 2 mm contour. Total required time was 25 minutes for computing 50 sections.

## CONCLUSIONS

1) A stereo camera system with CCD linear arrays and a personal computer was developed by the authors for automated three dimensional measurement of small object.

2) A special address generato for stereo matching and its software were developed by the authors.

3) From the results of experiment, it can be said that practical application to close range photogrammetry in near real time would be possible.

4) Further studies should be made to improve the processing time and to calibrate the geometric errors due to misalignment of linear arrays.

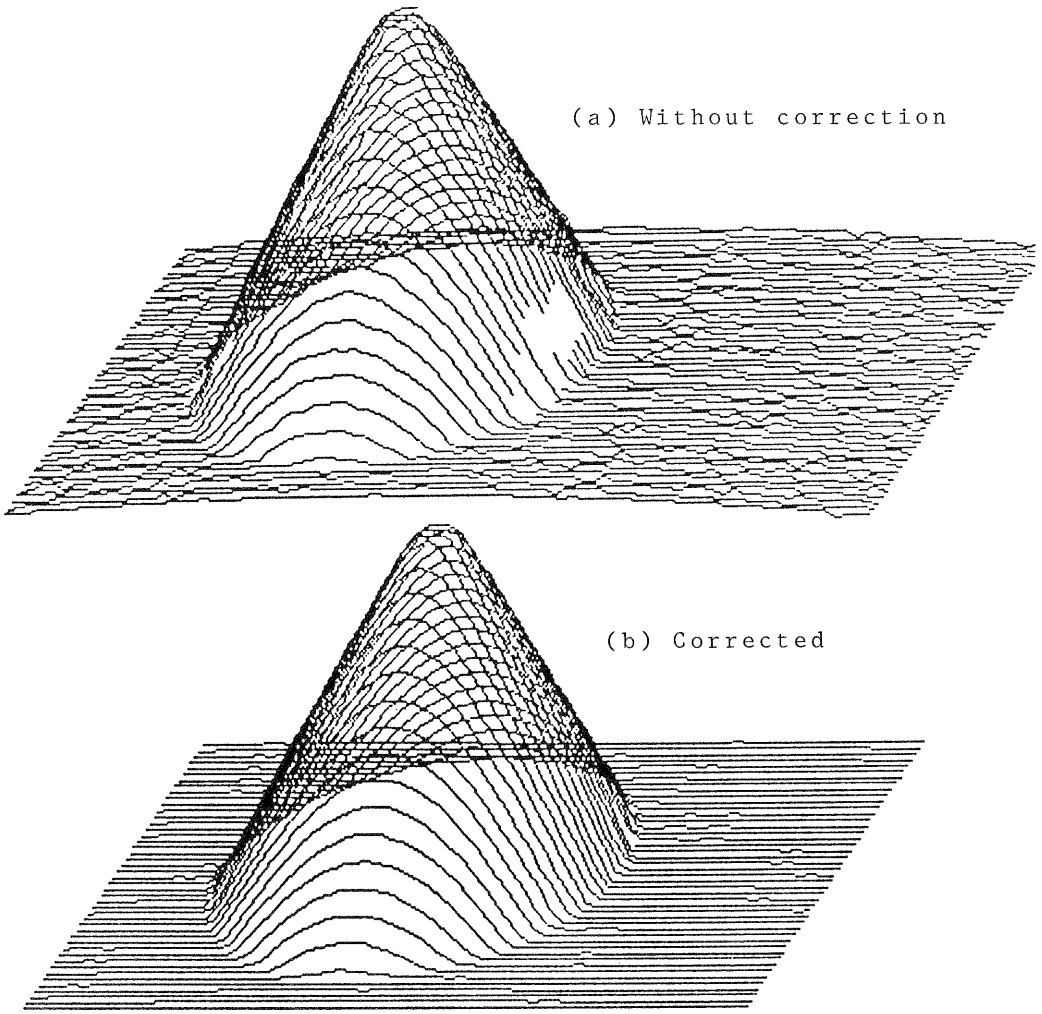
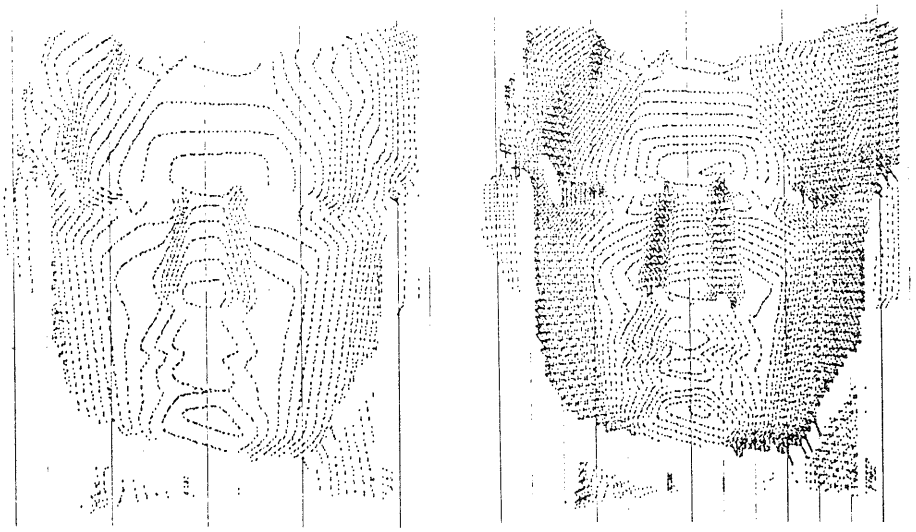



**Figure 3 Computer Generated Sections of a Cone**



(a) 5 mm interval (b) 2 mm interval

**Figure 4 Computer Generated Contour of Sculptured Face**