Reconstruction of 3-D Measurement Data

Hideyuki SAWADA, Masao MATSUMOTO-MORIYAMA,
Hideki FUKUDA and Takakazu ISHIMATSU
Dept. Mechanical Systems Eng., Faculty of Eng., Nagasaki Univ.
1-14 Bunkyo-machi, Nagasaki 852, JAPAN

Abstract

To reconstruct the real 3-D shape from the 3-D measurement data from the multiple directions, the reconstruction of the object on the basis of the mosaic processing of the 3-D measurement data are proposed.

In this method, to conduct the reconstruction, the connection points have to be identified among the overlap area between adjacent 3-D data.

In this study, the simple image matching method is adopted

for the identification of connection points , and this method is verified from numerical experiments.

1 Introduction

There are many methods in 3-D measurement such as stereometric methods, Moire interference fringe pattern methods and laser range finders [1] [2].

Usually these methods are applied only for the measurement from one direction.

Therefore, if someone wants to measure the global profile of the target, the measuring should be executed from multiple directions.

Measurements form multiple directions are needed typical when targets have large scale. The Authors had developed the 3-D profiling system for a human head, which can measure the 3-D profile of the object from all direction, however, cannot be applicable for the large objects [3].

To reconstruct the REAL 3 dimensional shape from the 3-D measurement data from the multiple directions, the Reconstruction of the object on the basis of the mosaic processing of the 3-D measurement data are proposed.

In this method, to conduct the reconstruction, the connection points have to be identified among the overlap area between adjacent 3-D data, which corresponds to the image matching problem.

Generally, the adjacent 3-D data are not parallel each other, and also the scale of each data is not the same. On the other hands, the simple image matching method such as the correlation method, SSDA (Sequential Similarity Detection Algorithm) and so on had been developed under the condition that such rotation and the different scale can be negligible [4].

In this study, in order to clarify the limitation of the simple image matching method, the numerical experiments from the simulated data are made.

2 Reconstruction

Fig.1 shows two 3-D image data obtained from two different directions. In this paper we suppose, the information about the distance is converted into gray level of the image.

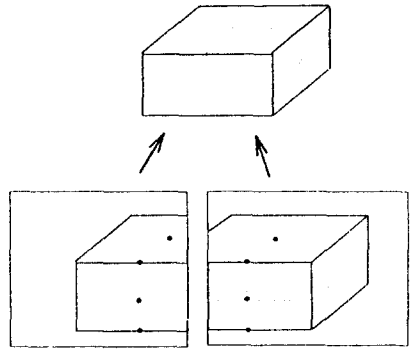


Figure 1: Schematic Diagram of the Connection

The geometric relations between two adjacent 3-D image data is calculated from the correspond points among the overlap area.

The calculated data are used to reconstruct the global 3-D profile considering the overlapping area.

3 Image Matching Method

SSDA (Sequential Similarity Detection Algorithm) method is faster than the other matching method because this method dose not need any pre-process and is based on the integer operation [4].

In SSDA the template is selected from an image, and the absolute value of the difference between the template and the other image (Target Image) are calculated and accumulated over the template by following equation.

$$R(a,b) = \sum_{x=a}^{a+m} \sum_{y=b}^{b+n} |I(x,y) - T(x-a, y-b)| \quad (1)$$

The accumulated difference are calculated over the target image and the point which minimize the accumulated difference becomes the matching point.

This scheme is shown in Fig.2.

4 Numerical Experiment

Difficulties of our problem are are 1) difference of scale and 2) rotation between adjacent 3-D datum. The difference of scale becomes negligible, in the case where the distance between the object and measuring system is considered almost constant during the measurements from each direction.

Furthermore, considering the range data of the target image, difference of the scale between two adjacent data can be compensated.

Therefore in this study, the matching accuracy affected by the rotation is analyzed from the simulation.

In this paper, instead of the range data, the image data are analyzed, because almost range data are provided as the image data.

As the image data, the Satellite Image data (Sakata Japan, from Landsat TM) are analyzed (See Fig.3). These two data contain the cover lap area.

An image data is intentionally rotated, and the 40 templates for matching is randomly selected from the other image. Fig.4 (a)(b) show these images. The matching accuracy is affected by the degree of rotation and the template size, these two parameters are changed as follows

- rotation angle (degree) : 0, 1, 2, 3, ... , 39, 40
- template size (pixel) : 3, 4, 5, 6, 7, 8, 9

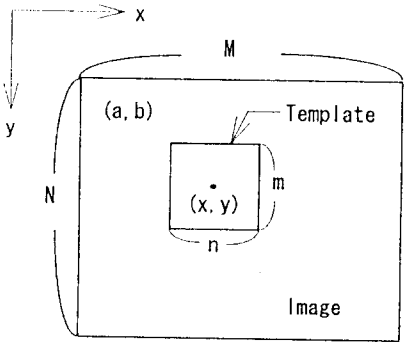
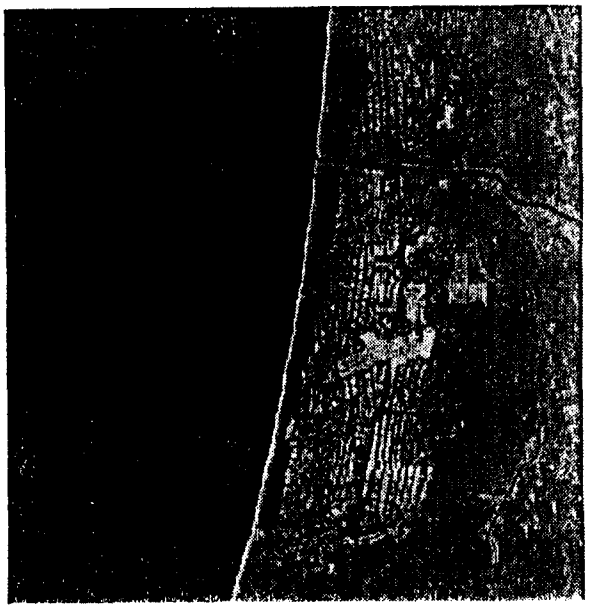
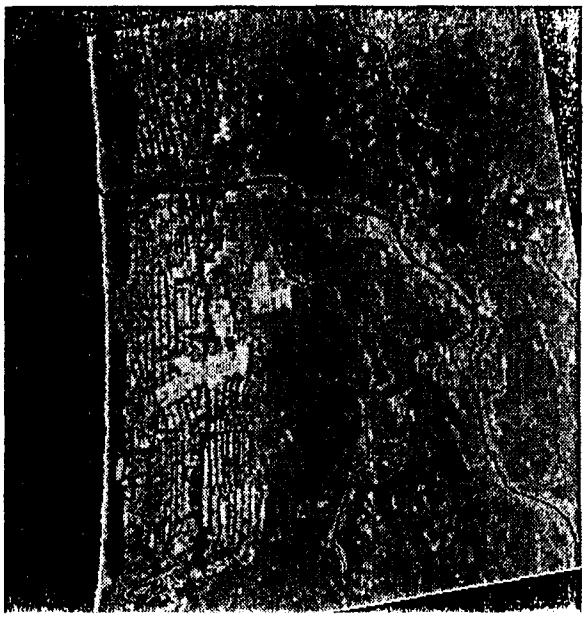


Figure 2: SSDA

Figure 3: The Whole image Data (Sakata Japan, from Landsat TM)



(a) Left image



(b) right image(10 degree rotated)

Figure 4: The Whole image Data (Sakata Japan, from Landsat TM)

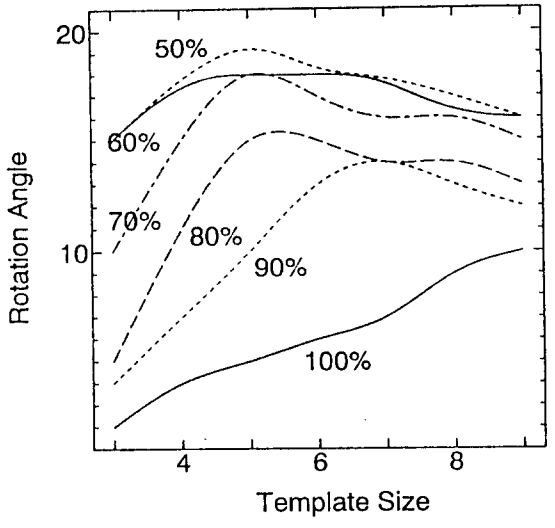


Figure 5: Matching Accuracy

As the index of the matching accuracy, the ratio of correctly selected matching point: r_c is used

$$r_c = \frac{\text{Correctly Selected Matching Point}}{\text{Total Number of the Matching Point}} \quad (2)$$

Table.1 and Fig.5 show the critical rotation angle which satisfy the ratio under the designated template size.

It can be estimated that the value of 80% of can accurately estimate the geometric relationship between a 3-D data, so the limitation of the rotation is 15 degree in the case of 5 × 5 template size. It can be assumed that condition is the critical condition of SSDA.

5 Conclusion

The result obtains by the simulation leads the following conclusion. It is clarified that the best template size is 5 × 5 pixel and the critical rotation angle is about 15 degree in the case which SSDA is used for 3-D reconstruction. For more general condition, the other matching method has to be used.

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