STEREO MEASUREMENT WITHOUT MARKERS FOR MOVING SOIL SURFACES

Anna Nakanishi[1], Masafumi Nakagawa[*2] and Toshiro Okamoto[*2]
[1]Master Student, Department of Civil Engineering, Shibaura Institute of Technology,
3-7-5 Toyosu Koto-ku, Tokyo, Japan; Tel: +81-3-5859-8401
Email:me11070@shibaura-it.ac.jp

[2]Department of Civil Engineering,Shibaura Institute of Technology
3-7-5 Toyosu Koto-ku, Tokyo, Japan;

KEY WORDS: Photogrammetry, Stereo measurement, Motion tracking, Land slide

ABSTRACT: Recently, 3D measurement of soil and sand surfaces has been required for a disaster observation and a construction field. We can generally acquire 3D coordinate values with stereo camera or laser scanner. Although current laser scanners can measure objects directly, a real-time data acquisition for moving objects is difficult due to a line scanning. On the other hand, stereo camera can measure moving objects in real time.
Therefore, we have proposed 'cross-matching methodology' consisted of a temporal matching with optical flows and a stereo measurement with a template matching. Firstly, feature points are tracked in temporal with optical flow estimation after feature point acquisition from a image. Secondary, the corresponding feature points are acquired from temporally synchronous images with stereo matching. Finally, 3D tracking for moving objects is applied with a combination of temporal and stereo matching without markers.

1. INTRODUCTION

3D measurement and tracking of Landslide movement has already been achieved with markers in a existing technique. [1] However, contactless measurement with sensors like laser scanners and stereo cameras hasn't been achieved, yet. Though the style with markers needs acceleration sensors and high cost, on the other hand, contactless style is dominant in terms of accuracy and feature point extraction. Therefore, we believe the soil and sand surfaces with homogenous textures are difficult samples to achieve fully-automated stereo measurement, otherwise manual stereo measurement requires surveyors high skills.
For 3D measurement of moving objects, selected feature points are extracted and 3D data is acquired about them. Because laser scanners can acquire data of a large number of feature points directly, data size becomes too large, and real-time measurement is difficult due to a line scanning style. Stereo camera enables extraction of feature points selected freely and accurate 3D measurement with a low cost.
However, from only synchronized stereo bitmap images, file list of temporal scene images, only animation including 3D coordinate and RGB data. For acquisition of three-dimensional morphology and texture of a object, and its movement from stereo images, it is necessary to acquire corresponding feature points between each pair of stereo images and among each of all temporal images. Not only rethinking the measuring system but also feature point corresponding is important for improvement of accuracy of 3D stereo measurement. [2] In this study, as a prepare for stereo 3D measurement of moving objects, 'Cross-matching methodology', composed of stereo matching and optical flow is proposed and confirmed with a experiment and sample data. We have conducted experiments to verify that our procedure can measure a soil surface using a stereo camera. Then, we have confirmed that our procedure can be used as a 3D measurement system without markers for moving soil surfaces.

2. METHODOLOGY

2.1 Cross-Matching Methodology

The two actions ;tracking a moving feature point in temporal and 3D measurement of objects with stereo camera are acquired for 3D measurement of moving objects. Then, as a preparation, corresponding points must be acquired both in each temporal and stereo image.
Therefore, we proposed 'Cross-matching methodology' described in figure1. For example, firstly, at the time t_1 and t_2, stereo matching is done on the feature points arranged in the each left image and the corresponding points are acquired in the each right image. Secondary, between the left scene images at t_1 and t_2, temporal matching is done and the corresponding points are acquired from t_1 to t_2 image.
Then, since stereo matching in scene t_2 and temporal matching in the right images are done, the two templates on the right images in scene t_2 are acquired on the each matching points. Thus, acquisition of the agreement between the two template on the matching points with another template matching; "Self-verification matching". (Figure 2)

Finally, we expect accuracy improvement and reduction of processing time with this techniques.

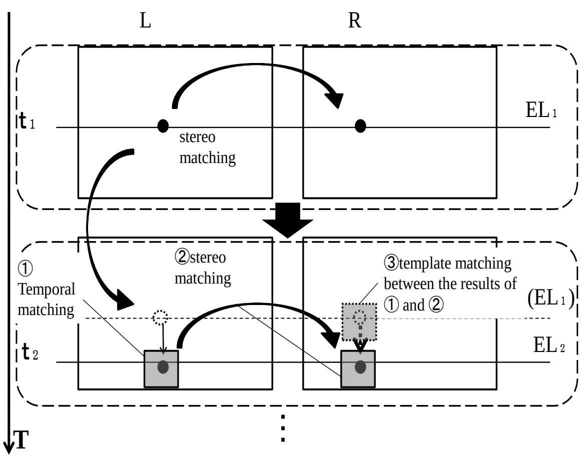


Figure 1. Cross-Matching methodology

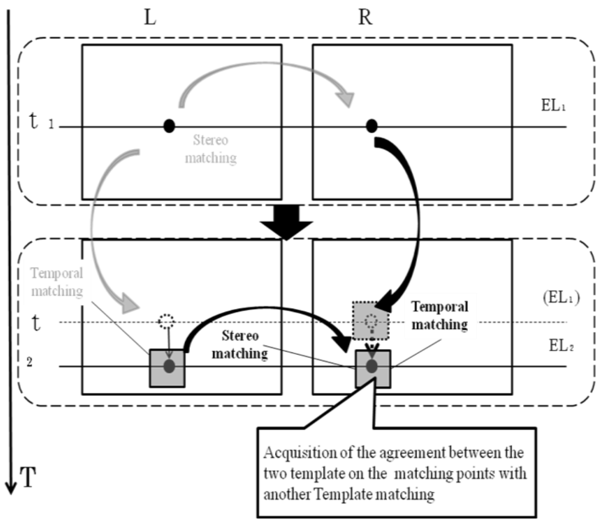


Figure 2. Verification of Cross-Matching methodology

1.2 Optical Flow Estimation

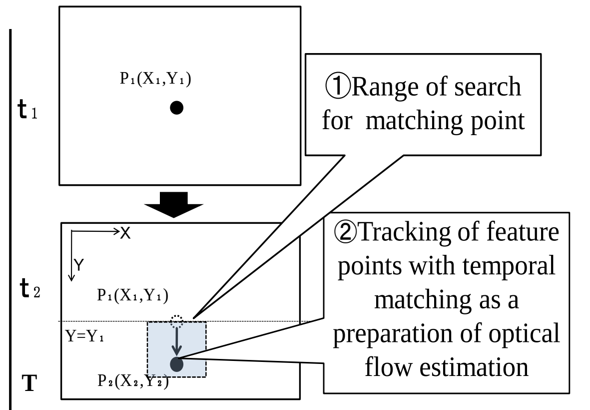
Optical flows in a moving object can be acquired with visualization of vectors of movements of objects in temporally continuous digital images.

Optical flow estimation is a kind of pattern recognition techniques. For example, about a pair of corresponding feature point's pixels in the two continuous scenes, the patterns of a few pixels square of neighbor zone are extracted and compared with correlation methodology. (Figure 3)

1.3 Correlation Methodology

In keeping with the past experiments, we decided to use Normalized Cross-Correlation methodology (NCC) and 21pixels square as the template size for stereo matching

The stereo images had been calibrated and rectified with Epipolar geometry, and the both corresponding feature points are on the Epipolar line. Thus, the range of search for the matching can be limited into a line. And, also due to depth of field, the range can be limited again. Therefore, the matching range is ultimately limited into the range described in Figure 4.



P1 : One of the feature point in scene t1 image

P2 : One of the feature point in scene t2 image (P1 after the movement)

Figure 3. Temporal matching with Optical flow estimation

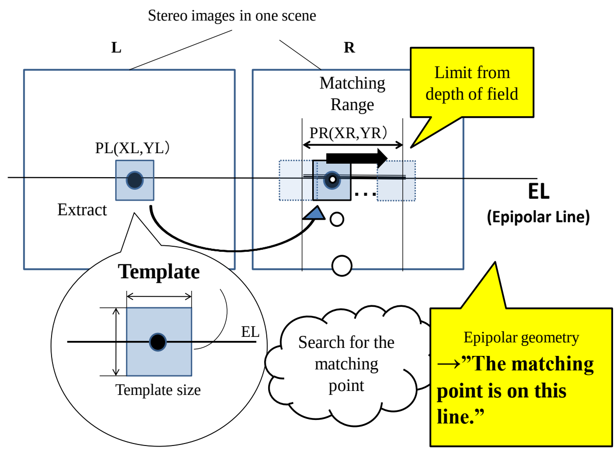


Figure 4. Stereo matching

2. EXPERIMENTS AND RESULTS

2.1 Experiments

In this study, we build a methodology of 3D measurement of continuous moving object and tracking through simulation experiments with some sample data. A small scaled land slide is imitated shown in Figure 6.Temporally continuous stereo images can be taken with calibrated stereo camera and rectified. (Figure 5,6) The accuracy of calibration is acquired as RMSE, shown in Table 1.
The environment of the experiment is as follows. Each two PC connected to the stereo camera controls each camera and synchronizes the right and left temporal images.

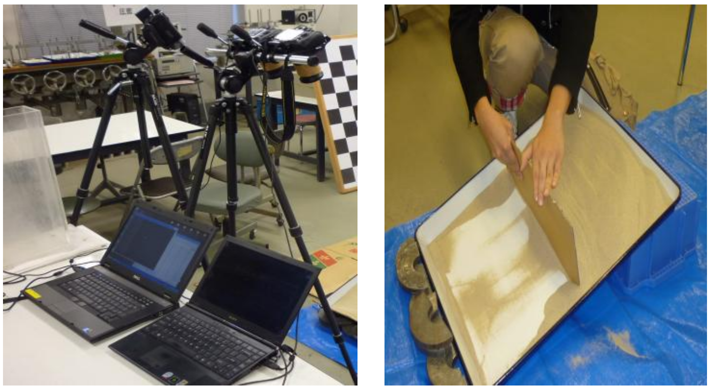


Figure 5,6. Situation of the Experiment

Table 1. Specification of Stereo Camera

Camera	Nikon D300
Focal Length	70mm
Baseline Length	150mm
Image Frequency	30FPS
Data Format	TIFF
Accuracy of cailbration	
RMSE(X direction)[mm]	0.157
RMSE(Y direction)[mm]	0.138
RMSE(Total direction)[mm]	0.148

2.2 Results

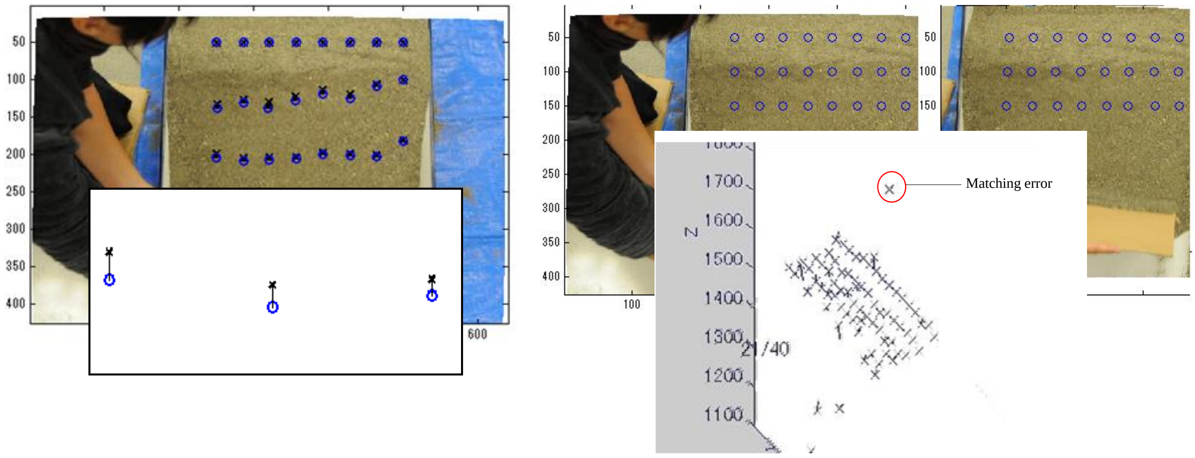


Figure 7. Stereo Measurement

We could visualize optical flows successfully like Figure 7. And We also done stereo matching successfully, but matching error sometimes occurred.
The image downward of Figure 7 is an image of one scene feature points visualized on 3D coordinates. For all that, the success rate is much more close to 100% compared with existing researches because a searching ranges in stereo matching is limited due to depth of field. (described in Figure 4) And, the processing speed improved as well as accuracy of both of stereo and temporal matching.
There're some stray points out of the real. We regarded them as matching error points with visual observation.
However, above results are acquired by individually following each procedure of two kinds of matching semi-automatically, so the functions of self-verification and shortening processing time are unavailable in this stage.

3. CONCLUSION

There are some to be solved as follows.

Fristly, whole cross-matching program, verification of matching points and error discovering procedures should be automated for improvement of measurement efficiency. Therefore, reconsidering inspection of matching and measuring accuracy is necessary.
Secondary, since a movement of a land slide is large scaled and integrated a large displacement in short time occur suddenly, real-time measurement is required for them.
Last, validity for all situation; close space, wide space, and baseline length, focal length, and camera distance, is also required.

4. REFFERENCE

[1] Masaki Imai, Masayuki Iwai, Ryousuke Shibasaki and Kaoru SezakiI: "The designs of slope failure detection system using wireless sensor network"The 31st Asian Conference on Remote Sensing(ACRS2010)2010.11.04 Hanoi, Vietnam
[2] Masafumi Nakagawa, Yoshihiro Kawai, Fumiaki Tomita: “Large-scale stereo for improvement of 3D measurement accuracy in gaze-observation” MVA2009 IAPR Conference on Machine Vision Application, May 20-22, Yokohama, Japan, p.58-61