

# DEVELOPMENT OF CONVENIENT 3D MEASUREMENT USING CONSUMER GRADE DIGITAL CAMERA: THE 3DIVISION EXAMPLES

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## ABSTRACT:

The authors have been concentrating on developing a convenient 3D measurement method using consumer grade digital cameras, and software “3DiVision” has been designed to perform convenient 3D measurements under the key words; 3Dimension, Digital image and Visualization. “3DiVision” has shown the capability to compute both exterior and interior orientation parameters simultaneously without GCP on the object space. There is still, however, issue which need to be confirmed before the 3DiVision may become operational. The problem is multipurpose use in various application fields. In order to confirm multipurpose use of the 3DiVision, the examples of the 3DiVision are given in this paper. In particular, cliff was measured by consumer grade digital camera from the view point of application to civil engineering, and it was confirmed that the accuracy for the horizontal, vertical cross sections and the volumes are almost same results compare with terrestrial laser scanning results.

## 1. INTRODUCTION

Recently, pixel numbers of consumer grade digital cameras are amazingly increasing, and there are many low-priced consumer grade digital cameras on the market. For example, 14 Mega consumer grade digital cameras have already appeared on the market in March, 2008. In these circumstances, convenient 3D measurement using consumer grade digital cameras are enormously expected in various application fields. Therefore, performance evaluations for consumer grade digital cameras have been investigated from the view point of digital Photogrammetry (Fraser, 1997; Kunii, et al., 2001, Noma, et al., 2002; Habib, et al., 2003). On the other hand, software for digital photogrammetry “3DiVision” was designed to perform convenient 3D measurement using consumer grade digital cameras by the authors (Chikatsu, et al., 2002), and “3DiVision” was improved using triplets images (Chikatsu, et al., 2006). However, there is still issue for multipurpose use of the 3DiVision in various application fields.

In order to confirm multipurpose use of the 3DiVision, triplet images for various objects such as cliff from the view point of application to civil engineering, stone Buddha, huge ginkgo and damaged car from the view point of conservation of cultural assets and industrial measurement were taken by consumer grade digital cameras. After brief explanation of the 3DiVision, various examples of the 3DiVision are given in this paper.

## 2. 3DiVision

The parameters in 3DiVision are exterior orientation parameters for the three cameras (left, center, right), and

interior orientation parameters which is common to three cameras. The main algorithms of the 3DiVision is simultaneous adjustment for triplet images, and the 3DiVision have capability to perform exterior and interior orientation simultaneously without GCPs. Figure 1 shows concept of the 3DiVision, and Figure 2 shows calibration procedures.

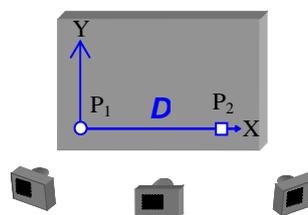


Figure 1. Concept of the 3DiVision

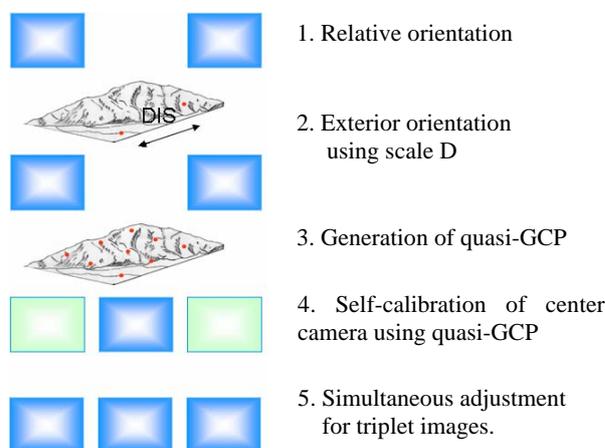


Figure 2. Calibration procedures



Figure 3. Triplet images for Cliff

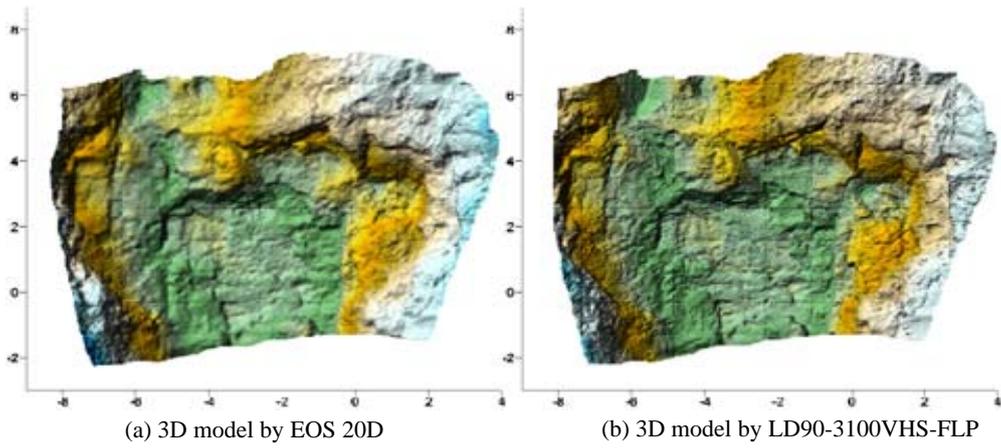


Figure 4. 3D model for the cliff

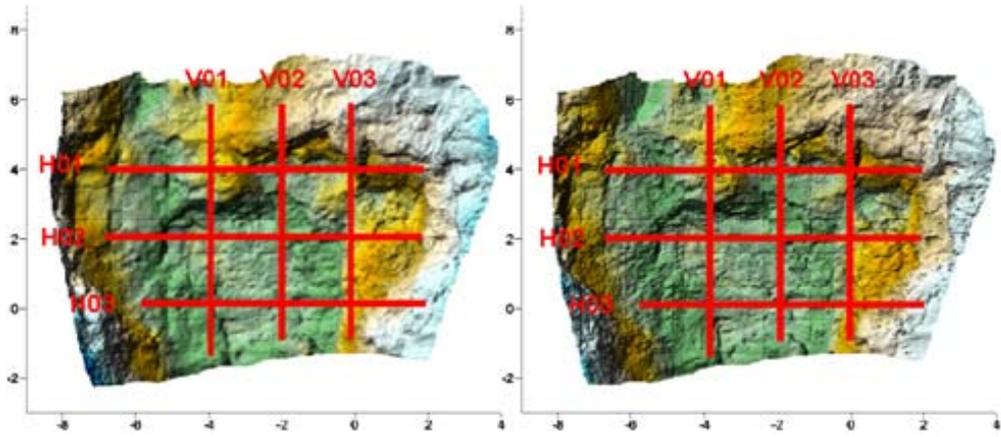


Figure 5. Position of cross sections

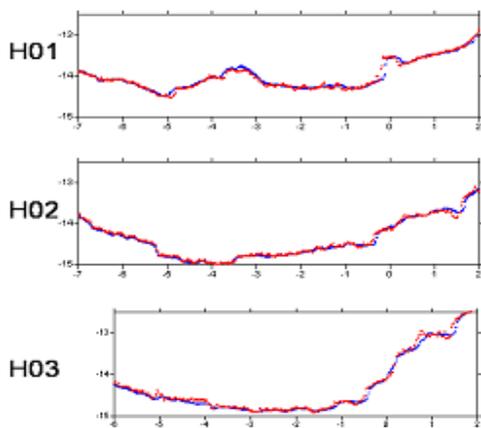


Figure 6. Horizontal cross sections

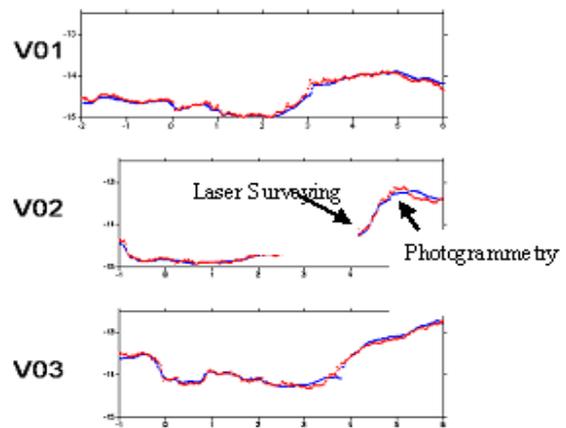


Figure 7. Vertical cross sections

### 3. CLIFF MEASUREMENT

In order to confirm multipurpose use of the 3DiVision from the view point of application to civil engineering, cliff was taken by the EOS 20D (Canon 8M). Figure 3 shows triplet images for the cliff and the cliff is facing with danger of collapse. Generally, these dangerous fields are measured by Total station or Terrestrial Laser Scanner as non-contact measurement in stead of common photogrammetry since common photogrammetry requires the setting of GCPs in the measurement fields. However, 3DiVision make possible photogrammetry for these dangerous fields using only scale distance such as surveying staff or distance between two feature points. Surveying staff just put in the fields in this investigation, and it can be found the surveying staff in the triplet images in Figure 3.

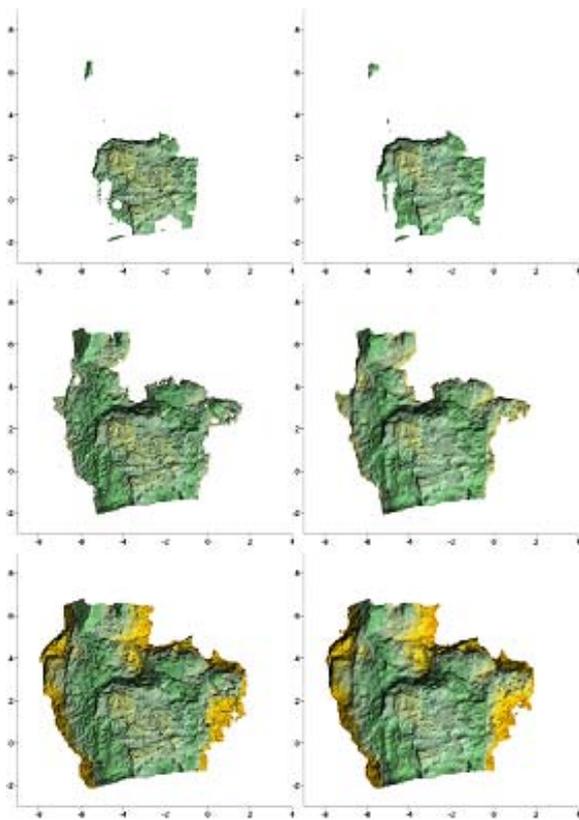


Figure 8. Section shapes at 0.5m (upper), 1.0m (center), 1.5 m (lower). Left side means photogrammetry and Right side means laser scanning.

On the other hand, horizontal cross section or vertical cross section, particularly volume is important element in civil engineering including accuracy aspects. With this motive, laser scanning using Terrestrial Laser Scanner, LD90-3100VHS-FLP(Riegl, accuracy;  $\pm 25\text{mm}$ , Pulse rate; 2,000 Hz) was performed. Triple images and laser scanning data for the cliff were taken with 15m altitude.

Figure 4 shows 3D model which were obtained by photogrammetric data and laser data respectively, and it can't find any significant differences between these 3D models. Furthermore, Figure 6 and 7 shows horizontal and vertical cross

sections for the place where is shown in Figure 5. Blue line shows cross section by photogrammetry and red line shows laser surveying in Figure 6 and 7. Similarly, it can't find any significant differences between these cross sections, and it can be seen 2m hollow at the maximum in horizontal cross sections. On the contrary, it can be seen obvious overhang shape which is about 2m at the maximum in vertical cross sections.

Finally, in order to evaluate practicability of 3DiVision from accuracy aspects, volume at the 0.5m, 1m and 1.5m section from the most bottom part was computed. Figure 8 shows shapes for each section, and it can't find any significant differences between these section shapes. Furthermore, Table 1 shows computed volume. Similarly, it can't find any significant differences between these except.

Therefore, it is concluded that the practical and convenient photogrammetry is accomplished by the 3DiVision.

	Photogrammetry	Laser Surveying
0.5 m	4.014 m <sup>3</sup>	3.978 m <sup>3</sup>
1.0 m	19.863	19.550
1.5 m	46.424	45.992

Table 1. Volume for each section

### 4. MEASUREMENT OF VALIOUS OBJECTS

In order to confirm multipurpose use of the 3DiVision in documentation of cultural assets and industrial measurements, triplet images for stone Buddha group (V570, Kodac, 5M), huge ginkgo(V570, Kodac, 5M) and damaged car (CyberShot, DSC-W35, 7.2M) were taken by the consumer digital camera respectively, and camera calibration was performed by the 3DiVision. Figure 9,10,11 shows triplet images and Figure 12,13,14 shows 3D model for each object.

It can be found circle targets in Figure 9 and 10, the distances between these target were used as scale. In the case of Figure 11, the distances between the wheels were used as scale.

From these application examples, it is concluded that the "3DiVision" is expected to contribute the various close range application fields since interior and exterior orientation parameters are calibrated simultaneously without any GCPs.

### 5. CONCLUSION

In order to confirm multipurpose use of the 3DiVision, the "3DiVision" was applied to cliff, stone Buddha, huge ginkgo and damaged car.

Horizontal and vertical cross sections, volume were investigated from the view point of civil engineering, and it was verified that the results which are obtained from photogrammetry show the same result compare with laser scanning data.



Figure 9. Stone Buddha



Figure 10. Huge ginkgo



Figure 11. Damedged car



Figure 12. 3D model of stone Buddha grope.



Figure 14. 3D model of huge ginkgo.



Figure 15. 3D model of Damedged car.

Furthermore, 3D modelling for stone Buddha, huge ginkgo and damaged car were investigated from the view point of documentation of cultural assets and industrial measurement, it was also verified that convenient photogrammetry can be achieved by the “3DiVision”. Therefore, it is concluded that the practical and convenient photogrammetry is accomplished by the “3DiVision”, and the “3DiVision” is expected to contribute various close range application fields.

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