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USING STEREO MATCHING 3D MODELS IN MONITORING HYDROTECHNICAL TORRENT CONTROL STRUCTURES

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Abstract: *The usage of terrestrial photogrammetry is also known nowadays, in most of cases, as terrestrial scanner application. In this paper a stereo matching 3D algorithm is presented in order to use it in monitoring the torrent control structures. The present paper objective is to highlight the possibilities of terrestrial photogrammetry. In the studied case, a 3D model of a masonry dam has been extracted from several paired photos. The main conclusion of the study is that the methodology represents a future step in monitoring the hydrotechnical structures.*

Key words: *3D model, monitoring, hydrotechnical structure.*

1. Introduction

The use of 3D information in monitoring hydrotechnical torrent control structures is not a new idea [11]. Several studies on extracting 3D models revealed the facilities of this kind of study [1], [2].

The methods used in surface reconstruction nowadays are either time consuming (topographical measurements of feature characteristics), either expensive (laser scans). From this point of view there is a large demand on cheaper and easier ways of 3D reconstruction.

Extracting 3D models using only a camera definitely resolves both problems on time consumption and high costs with traditional methods.

The usage of a web based 3D reconstruction service with a user friendly interface offers the technical support for users from other domains, like forest engineers.

2. State of the Art in 3D Surface Reconstruction

For many decades the 3D surface reconstruction has been researched and analyzed starting from pioneers like M.J. Hannah with his Ph.D. Thesis *Computer Matching of Areas in Stereo Images* in 1974 and continuing with many others. Still the problem is far from being completely solved due to many sources of errors. Most state-of-the-art methods rely on first using local measures to estimate the similarity of pixels across images and then on imposing global shape constraints using dynamic programming, level sets, space carving, graph-cuts, PDE or EM [6].

The problem of using many of the methods and algorithms in 3D surface reconstruction remains the descriptors used in stereo pair matching. The power of algorithm itself is enhanced by the pairs identified with the descriptor. The descriptor

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itself is a mathematical distance function of searching matching points in the pictures. The most common descriptors used in 3D reconstruction are SIFT, SURF, NCC or Daisy. The difference between the descriptors is given either by the radius of search or by the direction of the function (Figure 1).

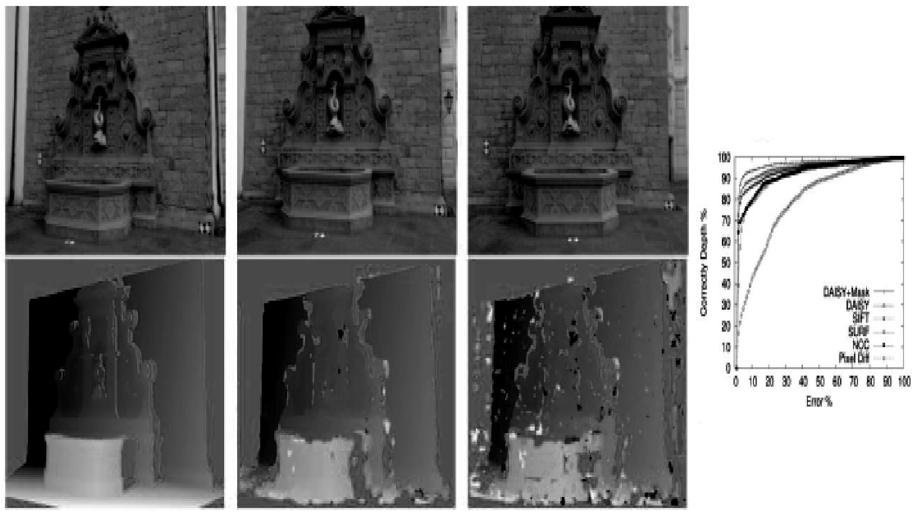

Fig. 1. *Comparing different descriptors with ground truth* (*first laser scan, second DAISY, third NCC*) [6]

3. Material and Method

In the hydrotechnical structures monitoring activity, several parts (e.g. apron, spillway, wings etc.) are taken into consideration for characterising the behaviour and dysfunctionality of the works [3-5].

In this activity the tri-dimensional characteristics of the component parts are mandatory. The 3D model of the hydrotechnical structures solves the problem of measuring the characteristics in the field.

The method consists in taking pictures of the hydrotechnical structure from different positions which cannot exceed a 12 degree parallax angle [9], [11] (Figure 2).

For taking the images for hydrotechnical structures a CANON EOS camera was used.

The pictures are stereo-paired using the NCC descriptor.

The NCC descriptor uses at first pairs of pixels located in two separate pictures (Figure 4) and reconstructs the x, y, z coordinates of a pixel after triplet matching (Figure 5). The matching of the triplets is mathematical similar with a triangulation and consists in finding triplets with enough matches between both images 1 and 2 and images 2 and 3.

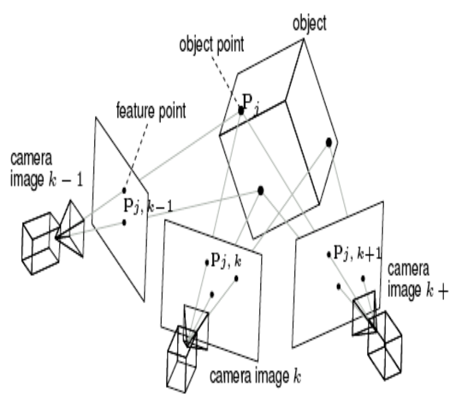

Fig. 2. *The projection of a 3D object point P_j in the camera image* [8]

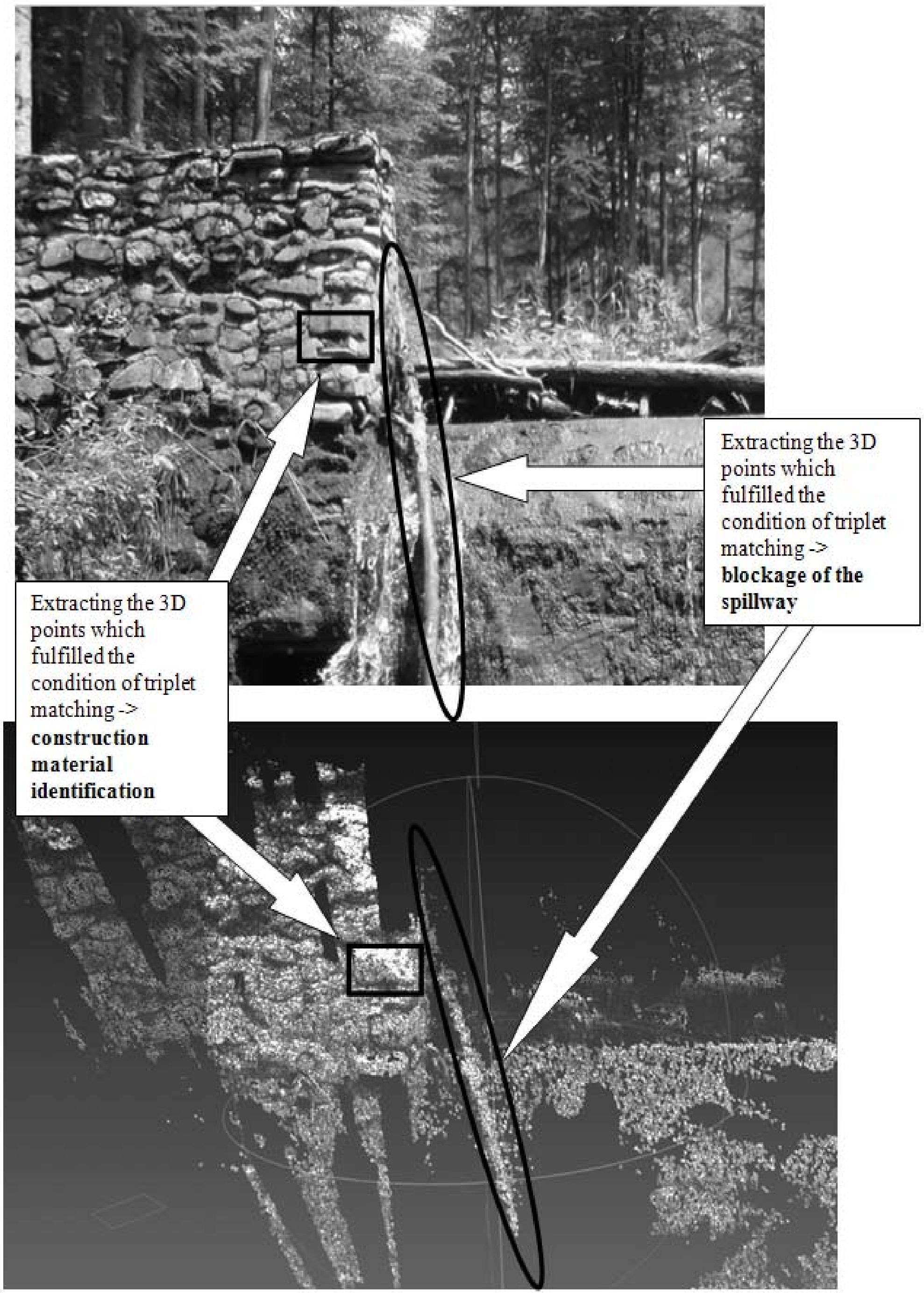

Fig. 3. *3D reconstruction of some characteristics of the dam based on 3 images stereo-restitution*

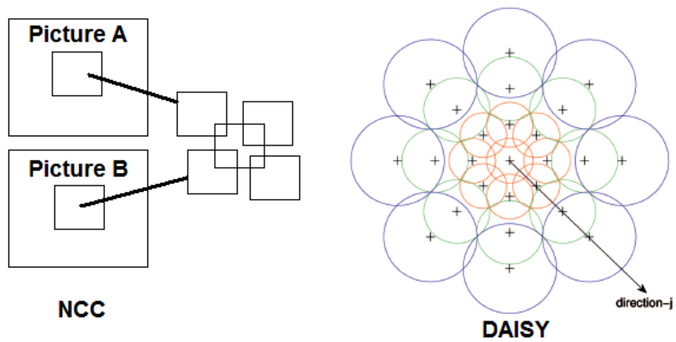

Fig. 4. *The NCC and DAISY descriptor matching methods*

The 3D model reconstruction is based on creating a network of irregular triangles (TIN) also called meshes from the points calculated with NCC descriptor.

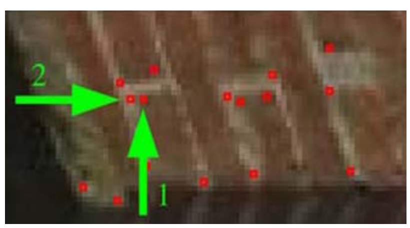

Fig. 5. *Identifying pixels 3D coordinates using triplet matching* [7]

The position of the camera is not influencing the algorithm [10]. In addition if the differences between the camera positions are small, the pictures contribute to a better identification of the paired pixels.

Fig. 6. *Irregular position of the camera* [7]

4. Results and Discussion

The complexity of the 3D model reconstructed from pictures using NCC is influenced by the number of the pictures used in calculation, the angle between picture views and picture resolution.

As shown in the application (Figure 3), the 3D model offers a lot of real scale information about the status of the hydrotechnical structure.

For example:

- Easy identification of component parts which has been affected by diverse behavioural events during the functioning period (in this case: the central spillway zone, left wing of the watershed);
- Accurate reconstruction of the adopted constructive solution;
- Precise identification of construction material (in this example: the masonry);
- Identification in the left part of the model of the affected parts by disaggregation;
- Identification in the lower part of parts affected by water erosive degradation;
- Positioning the floating elements which are blocking the apron and the spillway;
- Possibility of establishing the blocking proportion of the spillway.

This kind of usage of photographs is a new approach in monitoring the torrent control hydrotechnical structures and research must be conducted in the future to better quantify the advantages and disadvantages of the method.

Using minimum logistic support (photo camera, open-source software, laptop) there were extracted 3D characteristics similar to products extracted with expensive scanners.

Taking into consideration the case presented above, strong and weak points have been identified.

As strong points there can be mentioned:

- Low costs;
- Fast application and extraction of 3D model;
- High precision of the model;
- Easy usage in the field;

As weak points there can be mentioned:

- The algorithm may introduce unreal information;
- Manipulation of the model needs experimented users;
- Scale of the model can be affected by errors.

5. Conclusions

The present paper objective was to highlight the possibilities of terrestrial photogrammetry, based on simple tools and clever algorithms of stereo-restitution.

The explained technique in this paper can be promoted and successfully applied to torrent control hydrotechnical structures monitoring. The method itself doesn't need expensive logistics or superior training of the operator who takes the pictures.

The proposed technique is suitable both for evaluating the physical status of the structures during field trips and for estimating temporal dynamics of behavioural events repeating the action.

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References

1. Clinciu, I., Petrițan, C., Niță, M.D.: *Monitoring of the Hydrotechnical Torrent Control Structures: A Statistical Approach*. In: Environmental Engineering and Management Journal **9** (2010) No. 12, p. 1693-1701.
2. Clinciu, I., Lazăr, N.: *Efectele lucrărilor de amenajare a bazinelor hidrografice torențiale* (*Effects of Torrential Watershed Management Works*). In: Revista de Silvicultură **2** (1997), p. 12-18.
3. Clinciu, I., et al.: *Efectele lucrărilor de amenajare a rețelei hidrografice torențiale din bazinul superior al Tărlungului - amonte de Acumularea Săcele* (*Effects of the Torrential Hydrographic Network Management Works from Upper Tărlung Watershed-Upstream of Săcele Accumulation*). In: Research Contract no. 33 369, between *Transilvania* University of Braşov and Ministry of Education and Research, 2004.
4. Clinciu, I., Gaspar, R.: *Cercetări privind funcționalitatea lucrărilor hidrotehnice de amenajare a torenților* (*Research Regarding the Functionality of the Torrents' Control Works*). In: Revista Pădurilor **5** (2006), p. 3-9.
5. Gaspar, R.: *Norme tehnice pentru urmărirea comportării în timp a lucrărilor de construcții folosite în amenajarea torenților* (*Technical Norms Regarding Behaviour of the Torrents' Control Works*). Bucharest. ICAS - Ministry of Forestry, 1984.
6. Tola, E., Lepetit, V., Fua, P.: *DAISY: An Efficient Dense Descriptor Applied to Wide-Baseline Stereo.* In: IEEE Transactions on Pattern Analysis and Machine Intelligence **32** (2010) No. 5, p. 815-830.
7. Vergauwen, M., Van Gool, L.: *Web-base 3D Reconstruction Service.* In:

Machine Vision and Applications **17** (2006), p. 411-426.

8. Thormählen, T., Hasler, N., Wand, M., Seidel, H.P.: *Registration of Sub-Sequence and Multi-Camera Reconstructions for Camera Motion Estimation.* In: Journal of Virtual Reality and Broadcasting **7** (2010) No. 2, p. 1-11.
9. Triggs, B., McLauchlan, P., Hartley, R., Fitzgibbon, A.: *Bundle Adjustment: A Modern Synthesis.* In: Vision Algorithms: Theory and Practice, LNCS 1883 (2000), p. 298-372.
10. Xiang-Zhou, X., Hong-Wu, Z., Ouyang, Z.: *Development of Check-Dam Systems in Gullies on the Loess Plateau*. In: China Environmental Science & Policy **7** (2004), p. 79-86.
11. Zhang, Z.: *Parameter Estimation Techniques: A Tutorial with Application to Conic Fitting*. In: Image and Vision Computing **15** (1997) No. 1, p. 59-76.