Photogrammetric Week '11 Dieter Fritsch (Ed.) Wichmann/VDE Verlag, Belin & Offenbach, 2011

Towards a Next Level of Quality DSM/DTM Extraction with MATCH-T

TOBIAS HEUCHEL, ANDRE KÖSTLI, CHARLES LEMAIRE, DIETMAR WILD, Stuttgart

ABSTRACT

The Generation of digital terrain models (DTM) and surface models (DSM) from digital aerial photos is an important part in the processing chain of digital Orthophoto production. MATCH-T is certainly one of the prevalent tools in this scope and has proven its quality and productivity in different hardware environments since a long time in the photogrammetric market. However the increasing amount of data in today's projects pushes the demand for improved tools and requires even better performance in quality and processing features. This paper summarizes the status of the product and focuses on new features of MATCH-T's DSM extraction.

1. MATCH-T – A SHORT REVIEW

The MATCH-T DTM and DSM generation process and its specifics have already been reported in different papers. Krzystek, Wild 1992 summarizes the basic model of feature point matching, which has been extended later to a block based approach resulting in an effective way to use all available images for DTM raster area generation. First investigations concerning the MATCH-T performance can be found in (Krzystek, Ackermann, 1995), a study about the influence of image compression have been done already for digitized aerial photos for JPEG in 1995 (Robinson et. al., 1995) and extensions in order to support different image geometries have been implemented for satellite images geometry already in the 90ties and for ADS aerial images in 2007. For quite a long time the DTM raster file has been the final data product of MATCH-T. However with the request for 3D (2.5 D) data modeling (for example building model creation) the focus has been extended to digital surface models (DSM), an option introduced with the 2008 revision (Lemaire, C., 2008, Gülch, E. 2009). Some recent comparison of MATCH-T DSM data with LIDAR reference data have been published by Haala, N. et al., 2010, and have shown that digital image matching can compete with LIDAR for some applications. The potential of image based methods has been underestimated for quite some time.

2. REQUESTS FOR NEW DENSE DSM OPTION

The market has brought up new requirements during the last year for further improvement of the quality of DSM processing. The expectations have been set for:

- Better support for True Ortho generation
- Improvement of DSM quality in bad texture areas
- More details modeled with a higher density of the DSM
- Minimize necessary manual editing efforts
- Creation of suitable input data (or alternative to LIDAR) for automatic feature extraction (for example building model generation)

The specific requests to the MATCH-T product extensions have been:

- Extension to dense pixel based DSM options

- More detailed DSM
- Further support of all image geometries (frame, push broom, satellite)
- Processing time must not increase in large part for the dense DSM option
- Support for photogrammetric block size up to several thousand images
- Further applicable for distributed processing and multithreading
- Increase of throughput by DSM working areas
- Implementation of new filter applicable for large point clouds for automatic data cleaning

3. DENSE MATCHING

The base principle for 3D point generation from at least 2 images has been naturally not changed, which is simply the search of corresponding image content, its accurate definition and geometric intersections using given image orientation and camera parameters. Creating this correspondence even for every pixel in an image is a quite demanding task and solutions and different investigations for this problem have been published during recent years. Beyond doubt, the major progress for such algorithms and for establishing this correspondence (image matching) have been contributed by and published in the Computer Vision Community during recent years. For the basic two image case, there is probably only one location in the Internet, (Middlebury, 2011), where different methods of stereo matching approaches are getting evaluated and corresponding links to published papers can be found. Many different "flavors" of algorithmic approaches, 108 (June 2011) references are reported, which definitely show that the ideas how to establish stereo correspondence is still a problem with many possible solutions and there is no "once solved", always applicable solution present. The influence of different texture, color and lightening conditions in a 2 image stereo image case is still demanding, even for the evaluation of artificially created test data. For the application in real world aerial images not every algorithm is suitable, since we do have changes in lightening conditions during aerial flights, due to different time of image exposure over long and neighboring image strips. In addition one has to cope in aerial image applications with pixel data of up to 500 Megapixel for a set of 2 digital frame camera images leading to computational cost which are needed to be taken into account for proper algorithms being able to process several thousand aerial frame images in a single project setup.

4. NEW DSM QUALITY

The improvements in the quality can be visually best seen in images with GSD less than 1 dm. An example is shown in fig 1 and 2, a small snapshot of a detail illustrating the changes in density and noise reduction, from the last (5.3, see fig. 1) to the new (5.4, fig. 2) revision of MATCH-T DSM. In both figures the DSM is visualized by color coded terrain heights and black contour lines.

It can be seen quite clearly that the details for example at the right part of the building (Church) are much better modeled and a much smoother rooftop of the building is computed by the new MATCH-T DSM release 5.4.

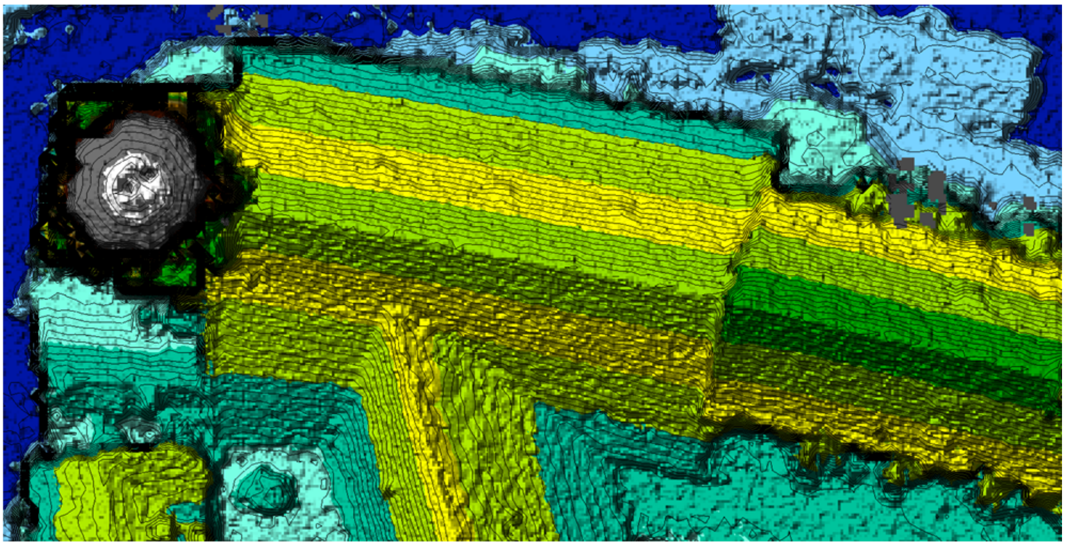

Figure 1: Current version DSM MATCH-T DSM 5.3

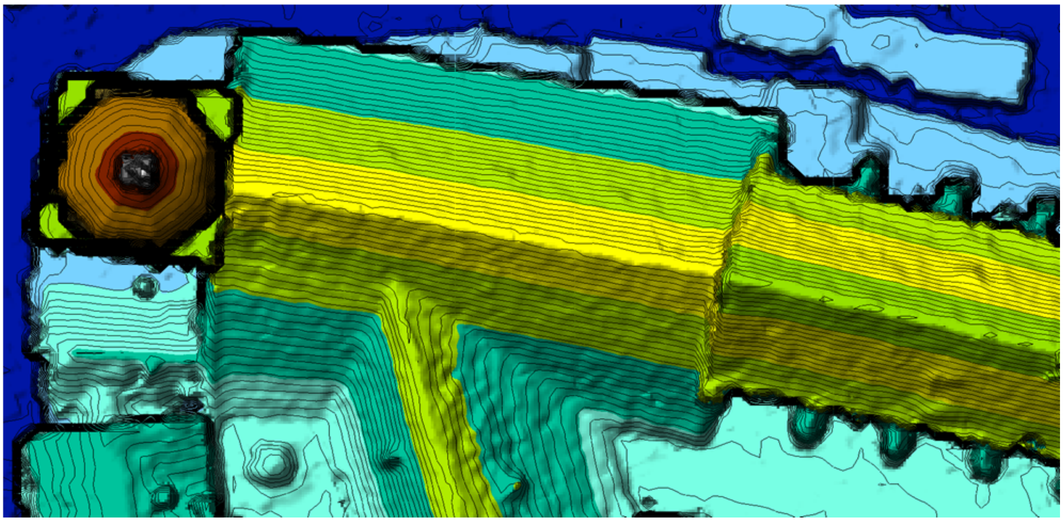

Figure 2: New version DSM MATCH-T DSM 5.4

5. PROCESSING TIME

Both versions (5.3 and 5.4) will request approximately the same computation time for DSM generation. But it depends heavily on the data (texture and percentage of overlap in flight and cross flight) and the image geometry. A case with a quite large reduction of the processing time for an example with digital frame cameras and the new matching strategy is shown in Table 1. More complex geometries in satellite and aerial push broom (ADS) applications require more processing time due to more complex functions for terrain-to-image and image-to-terrain transformation.

overlap	surface type	MATCH-T DSM 5.3	MATCH-T DSM 5.4
80/80	undulating	100%	53%
	mountainous	141%	59%

Table 1: Change in processing time version from 5.3 to 5.4

MATCH-T DSM in version 5.3 seeks for a much larger number of "online model combinations" to reach the requested number of successful points per matching unit. The reduction in processing time for the new version 5.4 is mainly influenced in this example by the nature of the new algorithm, which is trying to extract points for almost every pixel and is able to reach the requested point density much faster.

6. SUPPORT OF LARGE DATA SETS

The subdivision of large data sets in sub regions is supported by the option to define working areas and the use of an internal tiled point cloud format. Working areas enable to start with follow up processing steps before all working areas have been finished and provide a higher flexibility. An example GUI window is shown in figure 3 for a large working area. In that area, final point clouds are managed by a tile structure (for example 5 -10 Mio. points per tile) in order to select and load subsets of tiles depending on application context (editing, visualization) in the follow-up processing steps.

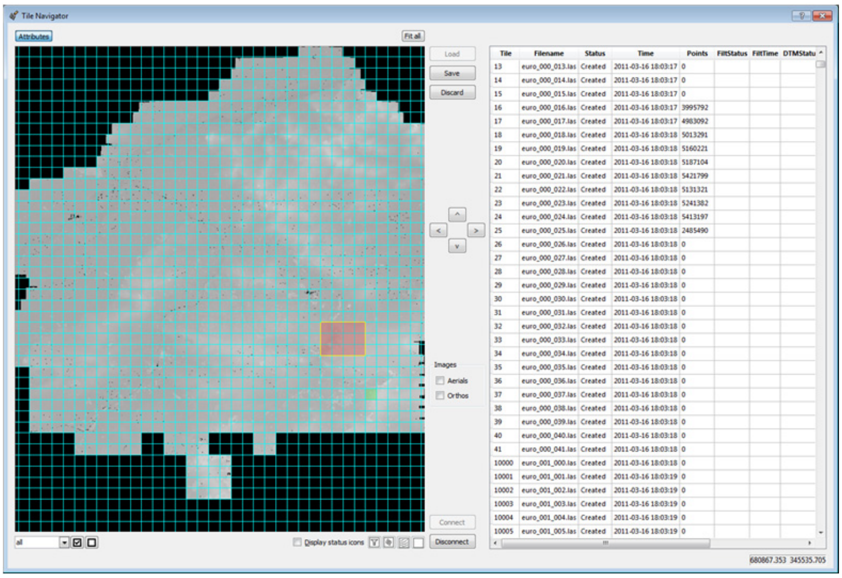

Figure 3: Index map of point cloud files

7. DISTRIBUTED PROCESSING

Since processing of large data sets in less time is always a requested but a challenging task, multithreading on single compute nodes and or in addition with distributed processing (DP) on a group of Personal Computer (PCs) or a cluster of connected nodes is a useful option when processing time is the major key to increase throughput in production. The Condor DP software (Condor, 2011) is one open available solution for getting batch task scheduling realized in an own private local network and is supported by MATCH-T DSM.

In July 2011 a project with IBM France and Interatlas (InterAtlas 2011) to study the use of MATCH-T DSM on a Windows cluster sharing a dedicated file I/O subsystem was started. Since the project is not finished until the final paper submission for the Photogrammetric Week 2011, more information will be presented in September 2011.

8. LARGE POINT CLOUDS FOR AUTOMATIC DATA CLEANING

The new MATCH-T DSM version implements a new algorithm to smooth the noise, to remove the gross errors, to keep the DSM edges sharp and to fill gaps in the data.

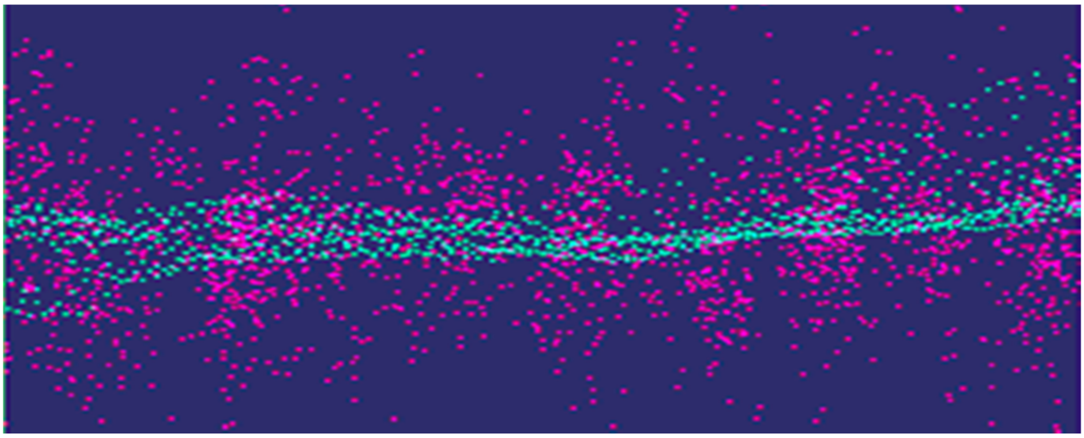

Figure 4: Reduction of noise in MATCH-T point cloud in a band of approx. 70 cm of a flat, bad textured area: new release 5.4 (points in cyan color) and last release 5.3 (points in red color)

Like in the previous version the gross error are eliminated with a robust analysis based on the redundancy of the input data. The smooth and sharp interpolation is a kind of adaptive filter that recognizes discontinuities in the DSM. If the signal to noise ratio of the DSM is below a specific tolerance the algorithm smooth the surface with the direct surrounding points, otherwise no interpolation is performed. Figure 4 shows clearly the benefit of the new interpolation and matching method.

9. CONCLUSIONS

The new features of MATCH-T DSM can be summarized by:

- DSM point cloud density is about 3 times higher by using default settings.
- Homogenous density in DSM can be obtained
- DSM point spacing in native image resolution is possible (default: 3x GSD spacing).
- Resulting DSM needs less or even no manual editing
- Significant reduction of noise in final point cloud
- Better smoothing in flat terrain and at flat object shapes
- Improved results in poorly textured areas
- Improved modeling of small details by DSM

10. REFERENCES

Gülch, E. (2009): Advanced Matching Techniques for High Precision Surface and Terrain Models. Photogrammetric Week 2009, Stuttgart.

Haala, N., Hastedt, H., Wolff, K., Ressl, C. & Baltrusch, S. (2010): Digital Photogrammetric Camera Evaluation – Generation of Digital Elevation Models. Photogrammetrie – Fernerkundung – Geoinformation (PFG), No. 2, pp. 99-115.

Krzystek, P. & Ackermann, F. (1995): New investigations into the practical performance of automatic DEM Generation. Proc. of the ACSM/ASPRS Convention, Charlotte, 1995.

Krzystek, P. & Wild, D. (1992): Experimental Accuracy Analysis of Automatically Measured DigitalTerrain Models. In Förstner/Ruwiedel (Eds.): Robust Computer Vision – Quality of VisionAlgorithms, Wichmann Verlag, Karlsruhe, pp. 372-390.

Lemaire, C. (2008): Aspects of the DSM Production with High Resolution Images. IAPRS, Vol. XXXVII, Part B4, pp. 1143-1146.

Robinson, C., Montgomery, B. & Fraser, C. (1995): The Effects of Image Compression on Automated DTM Generation. Photogrammetric Week 1995.

www: Condor (2011): http://www.cs.wisc.edu/condor

IBM (2011): http://www.ibm.com/fr/fr

InterAtlas (2011): http://www.interatlas.fr

Middlebury (2011): http://vision.middlebury.edu/stereo/eval