DRAGONFLY – INTERACTIVE VISUALIZATION OF HUGE AERIAL IMAGE DATASETS

B. Reitinger, M. Hoefler, A. Lengauer, R. Tomasi, M. Lamperter, M. Gruber
Microsoft Photogrammetry, 8010 Graz, Austria - bernreit@microsoft.com

WgS II/3 Multiple Representations of Image and Vector Data

KEY WORDS: Digital Photogrammetry, Aerial images, Interactive Visualization, Interaction, Large Datasets

ABSTRACT:

In recent years, digital aerial frame cameras got more and more attention in photogrammetry. A good example is the UltraCamX, which was introduced by Vexcel Imaging in Graz/Austria in 2006. This camera is able of taking a large sequence, multi-spectral (PAN, R/G/B/NIR), high resolution (132 mega pixel) images with high radiometric resolution. Aerial projects of the dimension of 3,000 multi-spectral images require over 1,2 tera byte disk storage and include over 480,000 mega pixel image data.One can imagine that handling this vast amount of images is getting a problem in the office. After each step of processing, the operator requires an in-depth quality control to ensure that all processed data fulfil the required quality expectations. At best, this is done not on an image-by-image manner, but should be done within the whole image block. This paper presents a new methodology for working with large blocks of high resolution aerial images produced by the UltraCamX. Our approach eases the handling of this large amount of data by using cutting edge technologies. In addition, we present an aerial triangulation application which is based on this visualization technique for fast image interaction.

1. INTRODUCTION

In the photogrammetric market, frame cameras got more and more attention in the last years, due to their integration in the standard photogrammetric workflow. Developments in the field of new sensor technology allow for more pixels and therefore also for higher resolutions. However, the produced data brings new challenges in handling and interacting with these images. Considering a typical project size of 3,000 UltraCamX images, over 1.2 tera bytes of image data are produced which stores over 480,000 mega pixel resolution. An efficient visual quality control over the whole block by considering the full resolution images is not a trivial task, and existing approaches and photogrammetric products are not designed for this vast amount of data.

This paper describes a new approach called DragonFly which is based on a fundamental work called Seadragon [LiveLabs, 2008; MacIntyre, 2008]. The latter is a key technology by Microsoft which enables users to seamlessly browse and zoom in large image collections.

2. RELATED WORK

2.1 The UltraCam-X Camera

In May 2003 the digital large format camera system UltraCamD (Leberl, F. et al., 2003) was presented and – three years later – the new large format digital aerial camera system, the UltraCamX was introduced to the international mapping market at the ASPRS 06 in Reno, Nevada.

The new camera was developed on top of the experience and success of three years of contribution to the digital sensor market and the digital photogrammetric source image acquisition.

The UltraCamX exploits the most valuable developments of the industry in the fields of sensor technology, data storage technology and data transfer. The most considerable advantages of UltraCam X are:

- Large image format of 14430 pixels cross track and 9420 pixels along track
- Excellent optical system with 100 mm focal length for the panchromatic camera heads and 33 mm for the multi spectral camera heads
- Image storage capacity of 4700 frames for one single data storage uni
- Almost unlimited image harvest due to exchangeable data storage units
- Instant data download from the airplane by removable data storage units
- Fast data transfer to the post processing system by the new docking station

The camera consists of the sensor unit, the onboard storage and data capture system, the operators interface panel and two removable data storage units. Software to operate the camera and process the image data after the flight mission completes the system.

Figure 1shows the UltraCamX with the sensor unit on the right hand side and the computing/storage unit on the left hand side (Gruber, M., 2007). The physical pixel resolution is 7.2 micron and the radiometric resolution is 12.7 (Honkavaara, E., Markelin, L., 2007).

Figure 1: The UltraCam-X digital aerial camera system.

2.2 Seadragon Technology

Seadragon is a technology that enables the smooth browsing of huge image blocks and makes four fundamental promises about access to visual information that set it apart from other technologies. Across any network, on any device, the speed of opening a visual space or of navigating around it is not affected by the size of the objects, but only depends on the screen resolution. In addition, the bandwidth also affects the performance of the visual representation. Therefore, a progressive multi-resolution transmission of data is required. Seadragon uses a special image data structure which is based on a pyramid file format, and does smooth interpolation between different image levels. However, the technology is developed for consumer-based images typically having 8-bit RGB image data. Higher dynamic ranges are not supported which is also a big limitation in the field of aerial cameras such as the UltraCamX. In addition, multi-channel support is required if the camera produces multi-spectral images, e.g. RGB and near infrared.

3. DRAGONFLY TECHNOLOGY

DragonFly uses the core functionality of Seadragon. Our main contribution is that we extended this functionality by adding the following features required for supporting the high dynamic range UltraCamX:

- Support for higher radiometric bandwidth
- Support for multi-spectral images
- On-line radiometric adjustments
- Support for external image position and orientation
- Vector overlay framework
- Image overlap visualization

Since the UltraCamX camera stores a radiometric bandwidth of 12.7 bits, we have to double the standard Seadragon image data container to 16 bits resolution. However, the HD photo image compression by Microsoft allows us to compress the image lossless in a very effective way (Srinivasan, S., Tu, Ch., Regunathan, S., L., Sullivan G., 2007).

The UltraCamX captures multi-spectral images, a panchromatic high resolution, and an RGB/NIR image. This means that we have to extend Seadragon to support this kind of image data.

Since the images store the high dynamic range, we have to apply a look-up table for sampling down to an 8-bit image for displaying it on the screen. This is done by using a shader program, see section 3.3 for further details.

The spatial alignment of the images is controlled by the incoming GPS/IMU data. This means that the index map aligns each individual image according to the interior and exterior orientation. By projecting down the images to ground level, we can display the real footprint of the image, and therefore also the full block overlay. Details about this visualization mode can be obtained from section 3.2.

DragonFly also supports different kinds of vector overlays which are required for different application. A scene graph-based architecture allows for efficient overlay rendering and selection by using a simple hit test strategy.

A specialized visualization mode is the so-called heat map which displays the degree of image overlap.

3.1 Image Data Organization

Before focusing on the different visualization types, this section outlines the image data organization. A DragonFly image is not a usual one plane image anymore, but uses a pyramid structure for fast access to multi-resolution image data. In addition, each pyramid level is split into so-called tiles which allows for extracting small data pieces during rendering. With this approach, the visualization performance only depends on the screen resolution and not on the resolution of the images or the number of images. Each individual tile in each individual pyramid level is compressed by using the Microsoft HD photo compression algorithm. It supports up to 8 channel images and provides a lossless compression for the 16 bit image data.

3.2 Visualization Modes

3.2.1 Index Map

DragonFly supports a wide variety of visualization modes. The first one is called the index map view and visualizes the available image data using their according position and orientation.

By using the interior and exterior camera orientation images are projected to the ground level in order to the real footprint. However, by varying the "virtual" ground level, we can scale up and down the image size. This allows for going from full overlapping images to a kind of index map (see figure below).
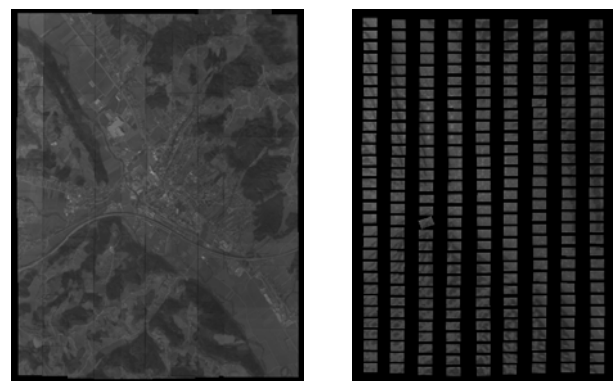

Figure 2: Aligned images in two different modes; left with original overlap, right with varying the "virtual" ground level in order to see the images side-by-side.

The index map view allows a first quality control of missing images or a high variation of the position and orientation data.

3.2.2   Heat Map

The heat map view is a more abstract visualization showing the degree of block overlay. We use a pixel shader program for calculating the degree of overlap by using the image footprints. In a second render path, we do a look-up in a 1D texture which maps the degree of overlap to a color coded image. A sample of the heat map is shown in Figure 3.
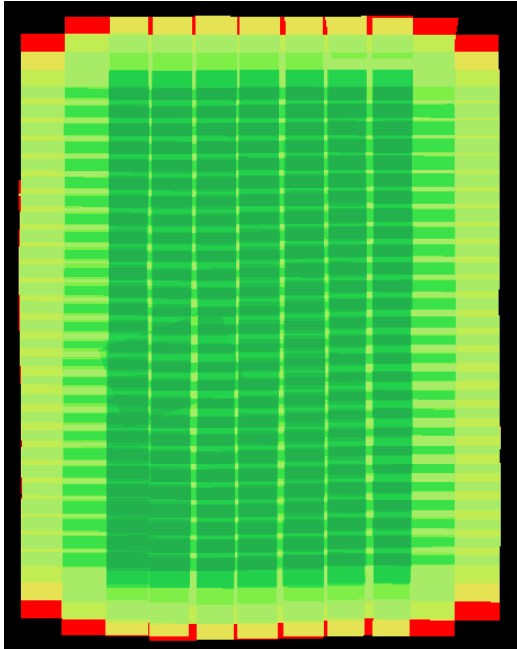

Figure 3: Heat map showing the degree of image overlap.

Dark green regions indicate highly overlapping regions, yellow means medium overlap, and red shows only little overlap. Since the heat map is calculated through a pixel shader, the mapping between the degree of overlap and the colors can be changed dynamically.

3.2.3   Vector Overlays

Vector overlays are important for displaying spatial data. DragonFly integrates a scene graph-based rendering pipeline which contains different vector geometry. Currently we support, line sets, face sets, and points. Figure 4 shows the index map of a project and the corresponding shot positions where the images have been captured.

The vector overlay framework also supports predefined symbols which can be used directly by any application. Since we use a scene graph-based structure we also support hit testing. Every symbol can uniquely be identified and therefore used for a hit test with the mouse. This is required for interacting with the overlay data in order to change their position interactively.
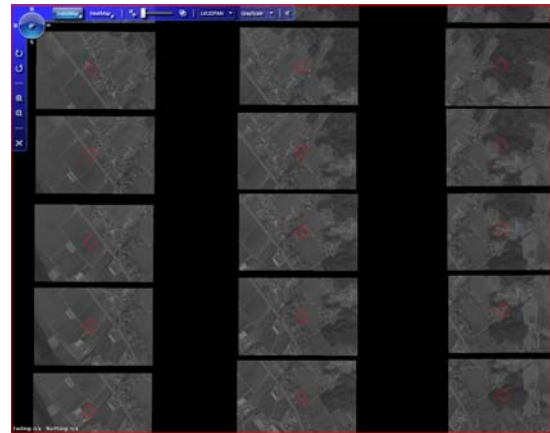

Figure 4: Vector overlay showing the shot positions of the images as a vector overlay.

3.3 Radiometric Adjustment

Since we store the complete high dynamic range in our image files, we have to down-sample the radiometric resolution to an 8 bit image in order to display the information. This down-sampling is done by using a pre-defined look-up table which can be specified by the user. Typically, a *log10* curve using a gamma adjustment delivers best results for 16 bit UltraCamX images. However, a 16to8 bit pixel shader program allows for applying any pre-defined look-up table.

3.3.1   On-line Color Composition

Since DragonFly supports multi-channel images, we can directly support the multi-spectral level 2 color image from the UltraCamX. The color file consists of four channels RGB and NIR.

Whenever this dataset is loaded by DragonFly, the user can choose between different channel compositions. For instance, either RGB or NIR is displayed by merging the required channels directly on the graphics card. This is again a pixel shader program doing the color composition.

4.   APPLICATION: ULTRAMAP-AT

DragonFly is the core technology being used for a new Microsoft product called UltraMap-AT which is an aerial triangulation software package. UltraMap-AT provides automated tie point collection, photogrammetric bundle adjustment and guided ground control point measurements using the DragonFly technology. The workflow of UltraMap-AT is shown in Figure 5. The input of the aerial triangulation (AT) package is UltraCam images with optional position and orientation information. By using a feature-based tie pointing approach, an initial orientation is calculated. The result can immediately be viewed within the DragonFly environment as a first quality control. The next step in the AT workflow is the interactive point measurement. By providing measured 3D ground control points, we re-project the 3D points into the affected images and give a good guess for the initial position. The projections are displayed as vector overlays and are drag-able in order to let the user to refine the measurement. A screenshot of the measurement overlays can be seen in Figure 6. After measuring the ground control points, a photogrammetric bundle adjustment calculates the best solution for the exterior

orientation for the whole block. The result can again be visualized within DragonFly in order to verify the results.
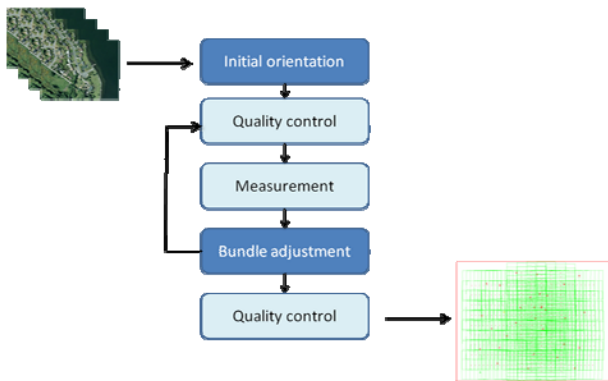

Figure 5: UltraMap-AT workflow using DragonFly for visualization and interaction.

5. CONCLUSIONS

This paper described a new way of working with large aerial image blocks by using and extending an existing technology called Seadragon. The main contribution of this paper is the adaption of Seadragon technology for the digital aerial images produced by the UltraCamX. We fully support a 16 bit image pipeline and allow for more than three channels in order to do an online color composition. In addition, we provide a vector overlay framework which allows standard geometry but also pre-defined vector symbols for interaction. An efficient hit test algorithm allows for interacting with the vector overlay data.

DragonFly provides the core technology for a new aerial triangulation software product called UltraMap-AT. Quality control and interactive point measurement is directly provided by DragonFly.
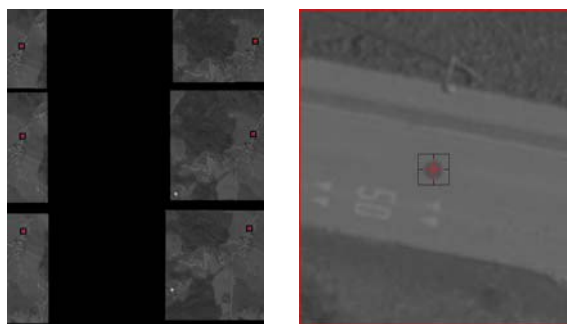

Figure 6: Measurement view of multi image projections (left); zoom-in view into one particular measurement point.

REFERENCES

LiveLabs, 2008. Seadragon. Microsoft Live Labs. http://live.labs.com/Seadragon.aspx.

MacIntyre, J., 2008. *Starren und Staunen*. Technology Review, April, 2008.

Leberl, F. et al., 2003. *The UltraCam Large Format Aerial Digital Camera System*, Proceedings of the American Society For Photogrammetry & Remote Sensing, 5-9 May, 2003, Anchorage, Alaska.

Gruber, M., 2007. *UltraCamX, the new Digital Aerial Camera System by Microsoft Photogrammetry*. Proc. of Photogrammetric Week'07, 2007.

Honkavaara, E., Markelin, L., 2007; *Radiometric Performance of Digital Image Data Collection – A Comparison of ADS40/DMC/UltraCam and EmergeDSS*; Proc. of Photogrammetric Week'07; pages 117-129, 2007.

Srinivasan, S., Tu, Ch., Regunathan, S.,L., Sullivan G., 2007; *HD Photo: a new image coding technology for digital photography*. Proceedings of SPIE - Volume 6696, 2007.

ACKNOWLEDGMENTS