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An integrated approach for orthoimage production

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ABSTRACT

Orthoimage and orthomosaic production has traditionally been a sequential process with many steps. With digital photogrammetry a part of the steps have been automated, but still the process requires a lot of operator effort. Now that digital cameras are entering the market and the number of images to be processed is increasing there is a clear need to automate the whole workflow as much as possible. One possibility is to use an integrated approach for orthomosaic production.

The integrated approach described in this paper is merging all the steps from tie point measurement to orthomosaic creation into one highly automated step. The method is based on global matching / object reconstruction and is now in the process of beeing implemented into a parallel processing software called Complete OBject Reconstruction Application – COBRA.

In this paper some early sample results of COBRA applied on forest and built-up areas are shown and discussed. These are two difficult areas for all automatic image matching and image mosaicking methods.

1. INTRODUCTION

Photogrammetry has been and still is in a phase of moving from analog to digital. Traditional film-based photographs have been scanned and processed digitally for quite some time already, but now digital cameras are entering the market with increasing speed. Although the new digital cameras have more sensor pixels than the old ones, they all still cover a much smaller area on ground than scanned photographs when having the same ground resolution. At the same time the areas to be mapped and/or processed are getting bigger. Many companies and governments want state- or county-wide orthoimage mosaics, even to be served to ordinary people through the WWW.

Because of this there is a clear need to speed up the orthoimage and orthomosaic production line. The traditional way of creating orthomosaics consists of four main steps, after the images have been captured and scanned:

1. Computation of the **absolute orientation** parameters of the input images. Automatic Aerial Triangulation or Direct Georeferencing can make this task automatically, if we can rely on the GPS/INS in the aircraft only and do not measure any ground control points.
2. Derivation of the **Digital Terrain Model** (DTM) or **Digital Surface Model** (DSM). A surface model is needed for true-orthoimages. This step is done automatically with many commercial systems, but some manual editing might be required afterwards.
3. Generation of single **orthoimages** using the results of the steps above. This is rather straightforward and can be done automatically.
4. Creation of the **orthomosaic**. Color balancing and seam line hiding is performed in order to end up with a nice looking mosaic. An operator might have to assist in finding the positions for optimal seam lines.

In this paper an integrated approach for ortho-image mosaic generation is briefly presented. **COBRA makes all the four steps mentioned above in a single automatic batch process**. As input it uses image data alone, with support from the GPS (and INS if, available) on board the aircraft. The role of the GPS/INS is only to give initial values for the location and attitude of the images. No manual measurements are needed. The approach is called COBRA, Complete Object Reconstruction Application. The method is somewhat similar to the global matching methods presented by Ebner and Heipke (1988), Helava (1997) and Wrobel (1987), and to the global object reconstruction method further developed by Holm (1995, 1999). Some earlier results of COBRA have been presented by Holm (2001).

2. COBRA

As mentioned in the introduction the traditional approach of making orthomosaics has many steps and is time consuming for the operator, even when many steps are automated. One of the problems with software based on the traditional approach of creating orthoimages is the placing of seam lines. This is often done manually. Finding optimal locations for seam lines is necessary because of a poor DSM, or because a DTM following the bare ground is used. There are automatic methods for placing the seamlines, but the results are not always perfect.

In COBRA no seam lines are looked for or even used. The reason is that COBRA uses a general model for digital photogrammetry, integrating area-based multi-image matching, point determination, object surface reconstruction, orthoimage and orthomosaic generation. Using this model, the **all the unknown quantities are estimated simultaneously** and directly from the pixel intensity values and from possible control information in a nonlinear least squares adjustment. The unknown quantities in the basic version of COBRA are the geometric and radiometric parameters of the approximation of the object surface (e.g. the heights of a digital terrain model and the brightness values of each point on the surface), and the orientation parameters of the images. Any desired number of images, scanned in various spectral bands, or captured by different sensors can be processed simultaneously.

Because of this COBRA makes the "best fit" DSM for the data in hand, and computes all the orthomosaic pixels based on all images. Therefore no seam line search is needed. Still no clear border between the input images can be found in the output mosaic.

3. TESTS AND RESULTS

Two difficult land-cover types for automatic image matching and mosaic creation methods are the forest areas and urban areas. In the following some sample results are shown for both cases. As the method still is under development the results are not final. The sample images are sub-images of a larger image mosaic. The scale of the original image data was about 1:7000, i.e. 1 pixel is about 8 cm on ground. The DSM was computed with 25 cm point spacing. All the images shown are reduced in size and resolution. The original images are captured with a small format aerial camera.

3.1. Forest areas

In Figure 1 a sub-image of size 256×120 m^2 of the automatically generated COBRA orthomosaic is shown. The images were captured in early spring and therefore some of the deciduous trees are still without leaves. In the creation of the orthomosaic all 11 images covering the sub area where used. None of the original images covered the whole sub area. The right edge of the sub image is at the edge of the whole image block. Still no borders between the individual images can be seen, and all the trees look nice and stand up straight.

The corresponding automatically generated COBRA DSM is shown in Figure 2. The DSM is color coded with dark blue being the lowest areas and dark red being the highest areas. The small building, the white car to the left of it and most of the individual trees in the forest can clearly be identified in the DSM. The locations of the trees in the DSM match exactly the locations in the orthomosaic. This is the reason why the trees stand up straight and do not lean in the orthomosaic, as they would have done in case a bare ground DTM would have been used in the orthoprojection. Therefore the COBRA result is a true ortho mosaic.

Figure 1: A 256×120 m^2 part of an automatically generated orthomosaic.

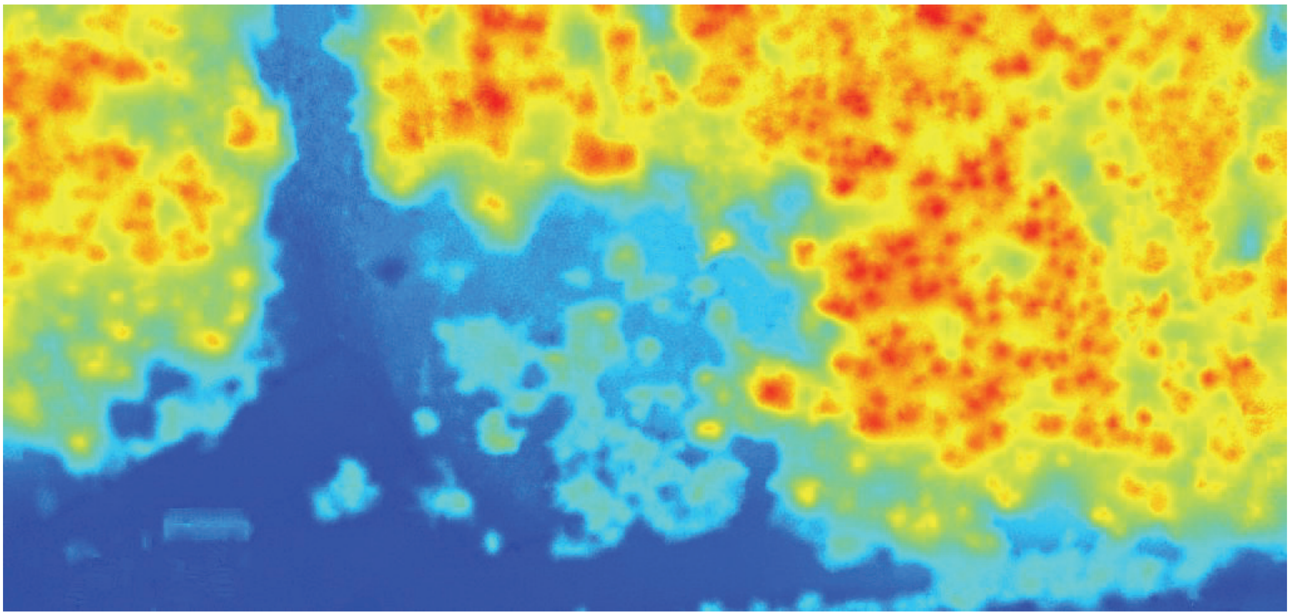

Figure 2: The automatically generated DSM of the same area as Figure 1.

3.2. Urban areas

The subject for this test case is a building and parking lot with some cars. In Figure 3 a 130×130 m^2 part of the automatically generated orthomosaic and DSM can be seen. These are now the pure results, without any post processing or filtering. The DSM can be seen in perspective view in Figure 4. Even though there are some small errors in form of peaks at the edges of the building and around the cars, it does not influence very much on the quality of the orthomosaic itself, as can be seen in Figure 3. Not all the peaks are errors; some of them belong to the bushes around the building. The vertical walls of the buildings and cars, which are not modeled perfectly, cause the peaks. One reason is that there is not much texture on the surface of the cars. Another reason is that all the pixels of the orthomosaic are treated similarly. The system does not know that there is a car or building in the object. We are now investigating several methods on automatically removing such peaks, and on making the walls more vertical.

Generally speaking the method still handles the object rather well, taking into consideration the repetitive texture on the roof of the building, the vertical walls, and the low textured areas on the parking lot. Most of the automatic image matching methods would have problems with this data set.

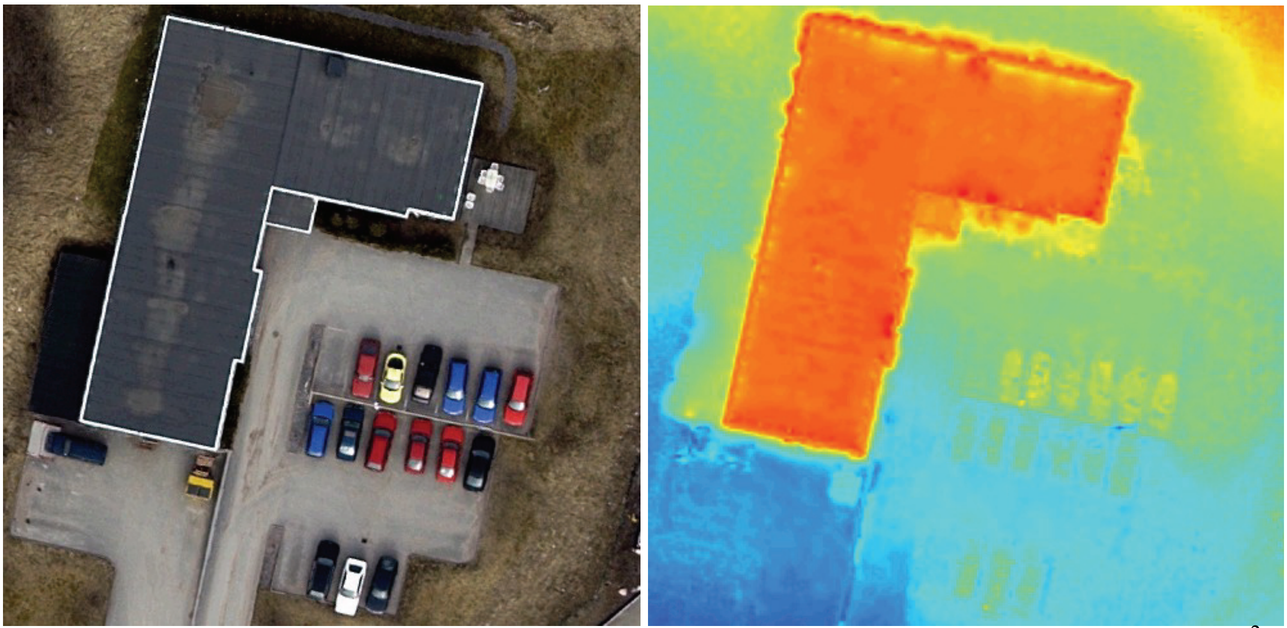

Figure 3: The COBRA generated orthomosaic to the left and DSM to the right. Size 130×130m^2

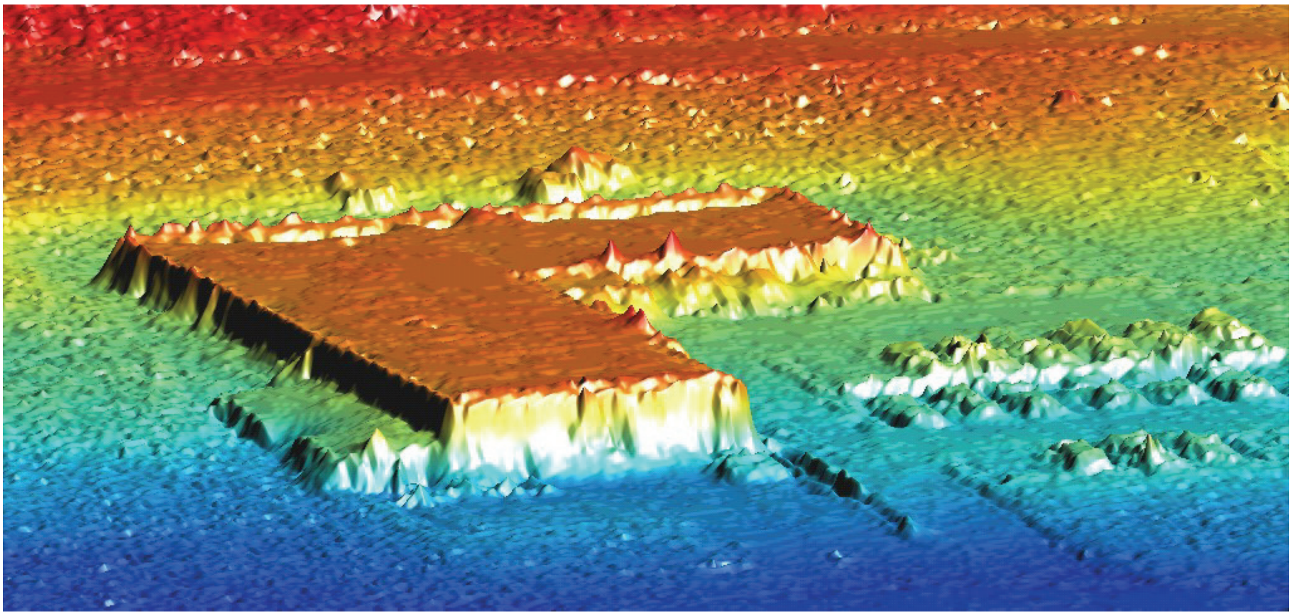

Figure 4: Perspective view of the area of the DSM of Figure 3.

4. CONCLUSIONS

The first results of COBRA using high-resolution small format camera data have been presented. The focus has been on traditionally problematic land cover types, namely forest and urban areas.
Based on these and earlier results one could say that the COBRA method has a big potential in replacing or at least complementing the traditional step-wise orthomosaic production methods. Especially now when the digital cameras are entering the market and the areas to be processed are growing. The one-step COBRA method is as good as fully automatic. Operator work is replaced by pure CPU-power.

5. REFERENCES

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