

Production of True Orthophotos in Practice and Various Application Possibilities

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ABSTRACT:

In the last years, the demand for detailed digital surface models in Europe has increased. The sectors of energy providers and mobile network operators need more detailed models for better calculations and more efficient implementation.

Forest Mapping Management GmbH (FMM) located in Salzburg, Austria, has a perennial experience in working with high-resolution digital surface models (DSM) and the following generation of true orthophotos. In the last 3 years, 7500 km² true orthophotos with combined DSM were generated and produced.

The high degree of automation of the process and the reduction of insufficiencies found in normal orthophotos and results needs a newer way of thinking for handling such data, and provides an abundance of new possibilities.

Since 2006, FMM developed and optimised a workflow to generate DSM and True Orthophotos, which allowed the data to be used by many applications, such as calculations of potential of solar collectors, actualisation of land register, documentation of damage caused to the environment or 3D building models and landscape-models.

Especially in the sector of forestry and agriculture, the data has become established and is used by FMM for the development of software applications in the forestry sector.

1. INTRODUCTION

Because of the increasing demand of digital surface models in Europe and the courage for innovative solutions of questions and applications, FMM has begun to work with true orthophotos and high-resolution digital surface models for 3 years. In these 3 years, the company made 7500 km² in Austria, especially in Salzburg, Linz, St. Pölten and the Styrian region.

Hermann Novak is leading the company with 18 employees since 20 years.

Starting as a little cartographical company in the forestry sector, FMM has developed to a modern photogrammetric company with its own aircraft and aerial camera (Vexcel Ultracam). The newest GPS/INS technics and digital workstations let FMM make the basis for working with high-precision data and analyses. More business parts are the software development, including webservices for the forestry sector and vehicle fleet management or the production of base data for municipal and private applications.

The intention of this paper is it to spark interest in the production of true orthophotos and digital surface models and to highlight their various applications.

In the following, the process of planning and production with its high level of automation will be described. We will also demonstrate a tested application from the forestry sector.

Finally we will try to make a look into the future of the production of true orthophotos and make a conclusion of the usage of the data now.

2. WORKFLOW

2.1 Description

Production depends on a really good planning and flight execution like any high-resolution flight. The planning is the base for the flight and should have the flightarea covered completely with an 80/80 overlap.

Often it makes sense to plan rectangular areas, because the overlap and the coverarea will be optimized and the following calculating process of the True Orthophotos will be uninfected by software bugs. The area should be covered in a single flight to avoid crossing shadows which create false interpretations in the automatic matching process. Generally it is recommended to plan a flightarea as compact as possible. Unnecessary images require additional time and delay the processing of the target area. After the flight and the processing of the images, an aerotriangulation (AT) will be calculated. Here it is important to have a good base, especially in the height. Better tiepoint measurements and height precision, allow the software to make better matching points and are the base for a clean and good DSM. To make a clean AT the input data should be correct. That means a high-precision camera calibration and optimal measured ground control points.

A short view of the production is shown in the following figure 1:

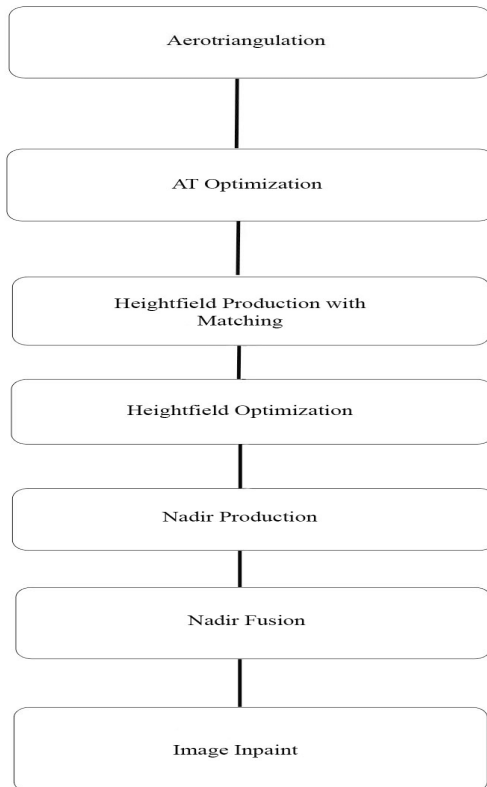


Figure 1. Workflow

In first step, the AT will be optimized. That means insufficient tie points will be eliminated and the data, especially the coordinates and angles of the exterior orientation, will conform to an optimal and readable datastructure for the software.

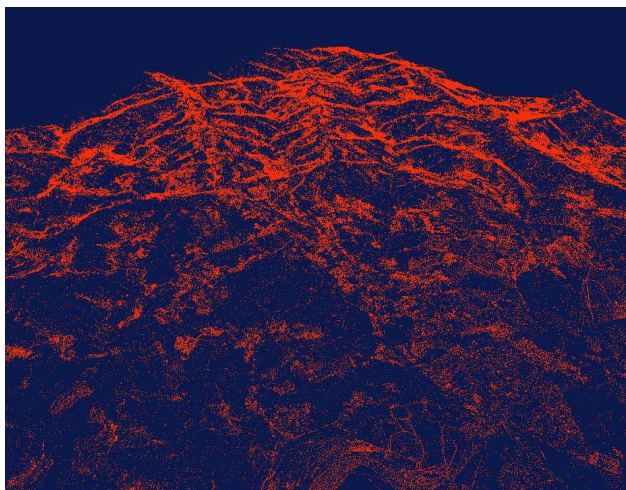


Figure 2. Tiepoints

In the next step the generation of the surface model will be started.

An automatic matching process goes over all images in the project. First it will produce a rough connection and a DSM.

This DSM will be corrected and refined in second part. In the normal way, a minimum of 100 points per square meter can be taken for the calculation of the DSM. That's an enormous pointcloud in comparison to the point density of a laser model. This process will be stated with a precision of ¼ pixel resolution which is specified in the program design. At the end it will be a really accurate digital surface model with a resolution of 12cm, which is the optimal resolution for successive tasks. Assuming like it will be flight in this scale. The resolution can differ, depending on scale. Up to 8cm resolution can be achieved.

This process needs a relatively long calculating time. 2000 images needs circa 10 days for matching.

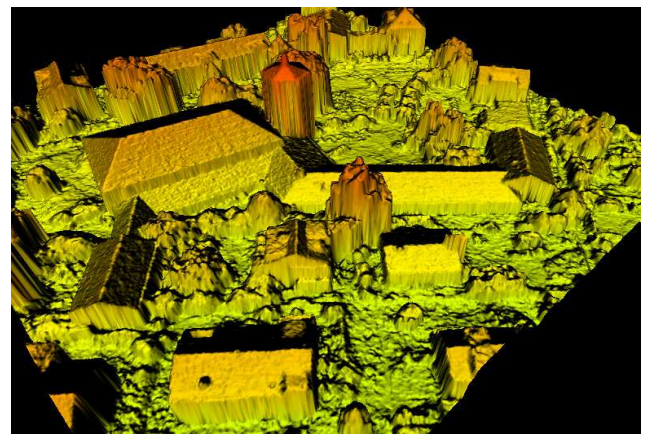


Figure 3. DSM in 3D View

After that the images will be straightened and rectified by the DSM. Nadirs will be produced from individual images, which are the base for the true-orthophoto production.

In connection with this step the nadirs will be connected to orthophotos with a special fading technique to guarantee an areacovered mosaic.

Black areas, which become by the different perspectives and overlapping, will be filled automatically with overlapping images at the end.



Figure 4. Trueorthophoto

2.2 Pros and Cons

The acceptability and utilization of true orthophotos should be compared by the pros and cons of the process and their properties.

The high investment of the flight, the calculating process and the high requirement of the hardware is accompanied by the higher automatism and the endproduct. The output is an orthophoto without any disposal or occlusion in the image, where all visual content will be shown in the correct location.

Furthermore, the long time needed seam line digitalisation of normal orthophotos to correct geometric mistakes is not applicable. Uses, like digitalisation or classification are easier and more detailed. It does not matter if the images are RGB or CIR. In both color spectrums, true orthophotos can be generated.

The nicest secondary effect is that the process of the true orthophoto makes a high resolution surface model as a co-product in the same resolution as the orthophoto. This DSM can be used by other applications and for analysis of questions.

The DSM can be the base for generating a digital elevation model. But it must be said that in large closed areas of vegetation, there are no points on the ground. In this case the generation of the DTM is very difficult and needs other data or more algorithms to calculate and interpolate the ground height.

A semi-automatic process is needed in these cases. With free sight to the ground there will be an accuracy and a level of detail not reached by normal models made by a laserscanner.

Mobile objects, like cars or motor bikes will be displayed diffused, confusing some users.

3. AUTOMATIC TREE EXTRACTION AND CLASSIFICATION IN FORESTRY

Especially in the forestry sector, the working with true orthophotos has proved itself and is the base for the forestry data acquisition in the house of FMM. This includes automatic tree extraction, inventory differentiation and volume calculation.

This information must be updated and renewed permanently, because the forest industry has to react quickly to exterior factors like bug infestations, storm loss and deforestation. A mostly automatic process on the base of true orthophotos is a maintask of the work of FMM.

3.1 Datastructure

For the analysis of forestry information, FMM uses true orthophotos with resolution of 12cm and their digital surface models. With the characteristic of the aerial camera (UltracamX) to make multi spectral images, it is possible to get CIR images in addition to RGB images simultaneously.

The images in the near-infrared range are used for the classification of vegetation data.

This grid data will be split in 500*500m tiles for faster analysis.

Furthermore a DTM from a laserscan flight are used to normalize the surface data. That is affected by the region, where the data will be analysed.

In mountainous regions it is advisable, but in a flat region, a normal interpolation can be used.

3.2 Tree extraction

Generally the tree extraction in the true orthophoto is easier than in normal orthophotos, because the tree have no disposals and are in correct position in picture and DSM.

The combination of DSM and DTM from laserscanning flight provides a quality control between both models and as well as a standardization of forestareas.

With that way it can be taken the relative height of the tree exactly and fast, which is not unimportant for the further development. A DTM is essential, because the consistence of the terrain in big forestareas can be caught in the produced DSM.

Based on an objectoriented algorithm, which registered local maximum in the DSM, will be detect the height and height changes, what from possible treetops can be suggested.

In addition to the position of the tree, information about the characteristics and the species of the trees can be detected. The algorithm was developed by FMM in cooperation with some universities in Austria and optimized for the high requirements of hardware by FMM.

High performance the hardware is needed, because of the large amounts of data. With an adequate tile format for the model, the working process can be controlled and accelerated. 380000 trees can be extracted in around 20 hours. That means an area with around 16 square kilometers.

After detection of all heights and topforms of the trees, it is possible to make a segmentation of the species of trees. In the first step it can differ between broadleaf tree and conifer. In a second step with the help of the CIR images, it can be analyzed and filtered for the species of the tree. Every species has its own characteristics.

With example measurements and available data, an accuracy of 90 – 95 % of the extraction in matured timber could be proven.

This statement relates to the mass of the timber in a body and the object extraction as comparably. The last 5 – 10 percent of error is a result of not visible trees in the area of vegetation.

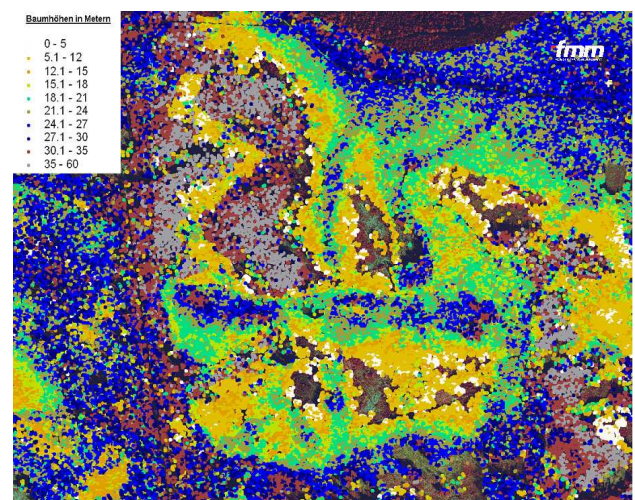


Figure 5. Tree height detection

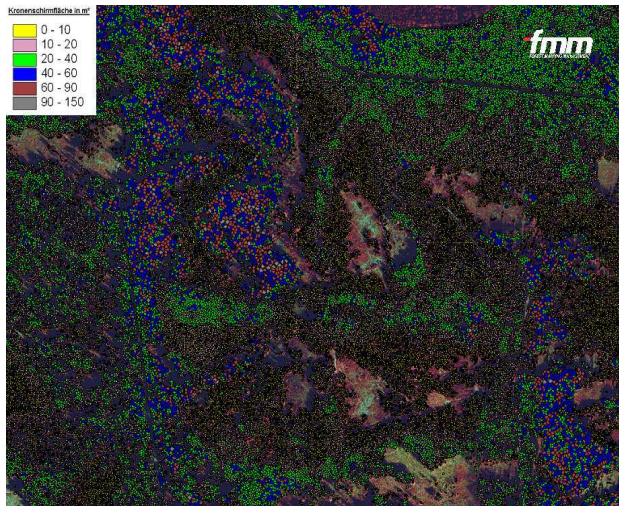


Figure 6. Treetop detection

3.3 Volume calculation and inventory

With the help of the determined tree heights and crown a volume calculation can be made.

In comparison with manual measurements and estimation, for the volume of the tree population a precision of 90% can be achieved.

With classification functions, like maximum – likelihood – classification, the inventory of the tree can be inspected. For this, some sample areas will be digitized and the sample areas will be used to improve the automated classifications.

These function have their fixed position in the way of analysing and in association with true orthophotos these function will reflect a high precision in horizontal and vertical position plus degree of automation.

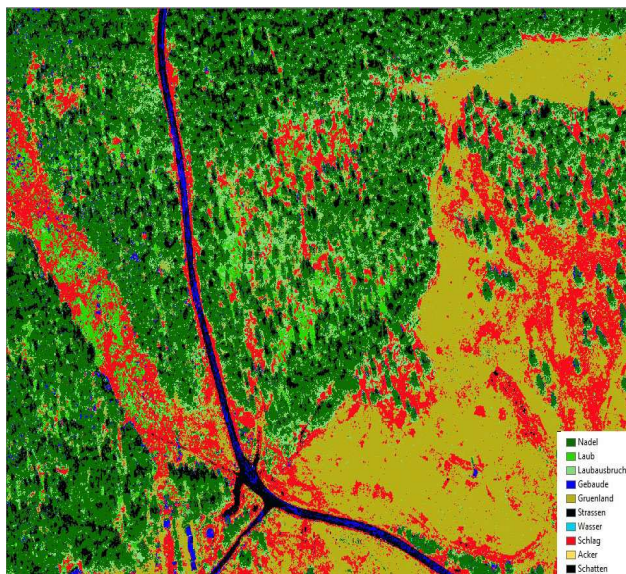


Figure 7. Classification

4. CONCLUSION

For three years, FMM has produced and used true orthophotos. 7500 km², mostly in Austria, are developed and analyzed. This data will be used in forestry reporting and their special applications. The images are to provide a basis for the inventory and correction of forestry information at stationary or mobile devices, on the other hand as illustration in webapplication for the forestry. Exactly in this economical sector these kind of orthophotos with the help of automatic analysis techniques reduces the investment of the data collection and processing at 70 %. Inventories after damages are made rapidly and rationally. Total costs for forest enterprise can be reduced, in spite of some minor expenditure in comparison to normal orthophotos.

In webapplication, for planning-, logistics or organisation software, unknown observer getting well with true orthophotos and can to adapt rapidly the displayed landscape. With that fact it is given, that the user, planer or driver can concentrate of the essential of his work.

Other customers, like energy providers uses the true orthophotos and digital surface models. An economization and cost saving can be localized for example by the analysing of cable ducts. Energy providers have a growing interest to work with such data, because it is qualified for a calculation of solarpotential or noise diffusion. FMM is working continuously to develop automatic methods on the base digital surface models and true orthophotos.

Cadastral authorities and municipalities are also customers, which need the data of FMM to standardize and upgrade the actuality and precision of the cadastre.

Generally, true orthophotos und digital surface models are known everywhere but the utilization is just beginning. The potential uses of this data is nearly inexhaustible and will be underrated by many people. There may be questions about the costs and the high hardware profiles, but with optimized operation and automatic techniques this handicap is to overcome. Permanent customers are proof of this.

FMM will continues this way and continues to search for automatic methods to accelerate the production and examination.

4. REFERENCE

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