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Editorial

Theme issue: "Digital aerial cameras"

Digital images of the Earth's surface are increasingly becoming a major product of photogrammetry and remote sensing. Such imagery is easy to interpret and everybody can make use of it without any prior training. These observations were the primary motivation for companies such as Google and Microsoft entering the business of digital aerial and satellite imaging.

Digital aerial cameras have a major share in this market when it comes to ground resolutions of well below 1 meter. For photogrammetric applications, digital aerial cameras have to fulfil high demands. The main advantages of digital aerial cameras over their analogue counterparts are a completely digital data flow line, a significantly improved radiometric image quality, together with the possibility to simultaneously acquire panchromatic, colour and near-infrared imagery. Some time has passed since high-end solutions were first introduced into the market during the 2000 ISPRS Congress in Amsterdam, and development in this area has been rapid and vibrant. Today, frame based as well as linear array cameras are available on the market and, although exact numbers are difficult to specify, approximately 120 high-end or "large format" systems (Leica ADS40, Intergraph DMC, Vexcel UltraCam-D), as well as around 150 "medium format" cameras plus many more "small format" solutions, are reported to be in operation world-wide. Moreover, these figures (researched by *Professor Gordon Petrie* of Glasgow University in May 2006) are increasing almost by the day.

Two different design philosophies exist for large format digital solutions: systems that operate as CCD push-broom sensors according to the three-line geometry, first successfully deployed in the mid-1990s by the MOMS space camera, and those that are composed of multiple CCD frames, which are combined together to deliver a virtual central perspective image. Large format systems are mainly being used by large photogrammetric companies and national mapping agencies, whilst medium and small format cameras are predominantly applied in fields including forestry, agriculture, and disaster management.

The rapid development of digital aerial cameras was recently highlighted at the ISPRS Hannover Workshop 2005 entitled "High Resolution Earth Imaging for Geospatial Information" and held in Hannover, Germany in May 2005. Discussions in Hannover mainly centred on the geometric and radiometric modelling of the complex sensor systems, the achievable accuracy on the ground, the added bonus for automation given the improved radiometric image quality, and potential benefits for practical applications. At this meeting the idea was born to report on digital aerial cameras in a theme issue of ISPRS Journal. A call for this theme issue was subsequently issued by the organisers of the ISPRS Hannover Workshop 2005 and ISPRS Working Group I/4, "Airborne digital photogrammetric sensor systems". A large number of contributions were received, including some updated versions of papers presented at the aforementioned workshop. The best papers received constitute the current issue.

Altogether five contributions were selected for inclusion in this theme issue. The first three papers describe detailed investigations into the achievable geometric accuracy of different systems. *Michael Cramer* from the University of Stuttgart, Germany, reports on a geometric performance test of the Leica ADS40. Based on a number of different missions with varying flying height and a large number of independent check points he found a standard deviation for generated coordinates in the range of 0.2 to 0.3 pixels for the horizontal coordinates and of 0.03–0.05% of the flying height for the vertical axis. Cramer also describes experiments with different GPS/IMU systems for determining image orientation and shows that whilst in theory no ground control points (GCPs) are necessary in the situation described, a sufficient number of GCPs is highly recommended, particularly in operational scenarios.

Along similar lines *Ramon Alamús et al.*, ICC Barcelona, Spain, investigated the Intergraph DMC. Various test flights were analysed in comparison to results from a film camera, again based on independent check points, and in one case also a digital elevation model obtained

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from a laser scanning flight. The authors focus on the role of self calibration and find a significant improvement if a separate set of parameters is used for each of the four DMC camera heads rather than a common set. They show that the pointing accuracy in image space is considerably improved, while the accuracy of the points in 3D is comparable to that from film imagery for similar flying height above ground.

Vexcel's UltraCam-D was the subject of the research by *Eija Honkavaara et al.* from the Finnish Geodetic Institute, Finland. Again, a geometric test field was used, and emphasis placed on a sound calibration concept including lab and field calibration as well as a self calibration component. Individual self calibration parameters for each lens were able to model the systematic errors found in the imagery. According to the authors a more sophisticated modelling approach for the UltraCam-D geometry may improve the results achieved.

The next two papers address the advantages of using digital aerial cameras when taking the complete photogrammetric processing workflow into account. *Nicolas Paparoditis et al.* from IGN, France, report on research and development undertaken as part of their digital camera project. Initially established as a research programme in 1991, the technology developed is now fully integrated in IGN production lines and since 2005 all IGN aerial imagery has been captured using digital cameras. The importance of the camera's modularity is stressed, with various configurations available for different applications. Problems and solutions to both geometric and radiometric calibration are described, the importance of further research into the former being highlighted. Improvements to the workflow processes are discussed, in particular with reference to image matching for digital surface model generation and the subsequent creation of orthoimagery. The authors foresee increasing convergence of remote sensing and photogrammetric techniques in coming years, a subject that is addressed in the final paper.

The main contribution of the paper by *Lukas Zebedin et al.*, VRVis Research Center for Virtual Reality and Visualization, Austria, is the development of an automatic processing flow line based on digital aerial images. Starting from image orientation and progressing to the extraction of vegetation and building layers, and the generation of digital elevation models, the authors take advantage of the unique possibilities provided by digital aerial cameras in integrating concepts traditionally belonging to remote sensing (multi-spectral classification) and to photogrammetry (3D reconstruction). They thus clearly show that digital aerial cameras are not only digital versions of analogue cameras, but invite users to re-think established methods for data processing and to develop new methodologies, which were not previously possible with traditional data.

Taken together these five contributions demonstrate the current state-of-the-art in digital aerial camera science and technology. The first generation of systems is currently being used on an operational basis and commercial contracts are increasingly insisting on digital aerial data capture. Investigations carried out by research institutes, often in cooperation with industry, point to possible improvements in design and processing workflow. These suggestions will almost certainly be taken up by the manufacturers in the near future, and further improvements in the quality of results and a faster throughput can therefore be expected. This may result in near real-time data and product delivery in the not too distant future, for while general mapping does not necessarily depend on extremely fast turn-around, real-time is an absolute requirement for applications such as disaster management. Thus, the development of digital aerial cameras may not only enable us to perform tasks better, which has already been proven, but also to undertake new tasks and challenges. The latter is obviously of major benefit not only to system manufacturers, but to photogrammetry and remote sensing at large, since it allows us to expand our field of activity.

Finally, we would like to sincerely thank everyone who has contributed to the realization of the theme issue. Particular thanks go to the authors for their interest in the topic, for submitting the papers, for adhering to the rather strict deadlines, and for the smooth communication throughout. We are also grateful to the reviewers, who have invested substantial amounts of time reading and commenting on the submitted drafts and have thus significantly improved the material of the theme issue. Last but not least, we express our thanks to George Vosselman, the Editor-in-Chief, for all the freedom and support he gave us in preparing and finalizing this theme issue.

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