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Editorial

Photogrammetry—The Science of Precise Measurements from Images: A Themed Issue in Honour of Professor Emeritus Armin Grün in Anticipation of His 80th Birthday

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Photogrammetry has been a cornerstone in mapping history and still functions as one of the key techniques in modern geospatial science and engineering. Since it was developed in the early 1900s, it has undergone a significant transformation in its technical concepts, realization, and applications. The technical landscape of photogrammetry has evolved from traditional semi-automated solutions for metric camera systems to more automated (often AI-driven) solutions for commercial-grade systems, centering on technical challenges such as camera calibration, bundle adjustment, terrain, and object modeling. These progressive developments are impossible without the dedicated figures who devoted their professional lives to photogrammetry.

This Special Issue is in recognition of Prof. Armin Gruen, a world-renowned photogrammetry expert who has consistently contributed to the field, to celebrate his 80th birthday.

In 1984, Prof. Dr. Armin Gruen, after a short professorship at Ohio State University (OSU), worked as a Professor and Head of the Chair of Photogrammetry at the Institute of Geodesy and Photogrammetry, Federal Institute of Technology (ETH) Zurich, Switzerland. Since 1 August 2009, he has been retired and is now the Chair of Information Architecture, Department of Architecture, ETH Zurich. He graduated in 1968 as Dipl.-Ing. in Geodetic Science and obtained his doctorate degree in 1974 in Photogrammetry, both from the Technical University Munich, Germany. From 1969 to 1975, he worked as a Research and Teaching Associate, and until 1981 as the Chief Engineer at the Institute of Photogrammetry and Cartography, Technical University Munich. From 1981 to 1984, he was an Associate Professor at the Department of Geodetic Science and Surveying, The Ohio State University, Columbus, Ohio, USA. He is a member of the editorial boards of several scientific journals. He has published more than 500 articles and papers and is the editor and co-editor of over 21 books and Conference Proceedings. He has organized and co-organized/co-chaired over 35 international conferences, and he has served as a consultant to various government agencies, system manufacturers, and engineering firms in Germany, Japan, Korea, Switzerland, USA, and other countries. He is the co-founder of CyberCity AG, Zurich, and 4DiXplorer AG, Zurich, Switzerland. He holds a number of international awards, among which are the Otto von Gruber Gold Medal (ISPRS, 1980), the Brock Gold Medal Award (ISPRS, 2008), Honorary Membership of the ISPRS (2008), and Honorable Doctorate (Dr.h.c.) from Aristotle University, Thessaloniki, Greece (2015).

This fairly exhaustive description of his research activities and achievements demonstrates his outstanding career. He contributed to science in multiple ways. Apart from his numerous publications and algorithmic breakthroughs, he also dedicated a substantial amount of time and effort to supervise and to educate doctoral students. As an inspiring, solidary and friendly supervisor, he trained many PhDs all over the World.

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In the Special Issue, we have collected 11 excellent contributions mostly from colleagues who had worked with Prof. Armin Gruen during various stages of their careers. These contributions span diverse subtopics of photogrammetry, including camera calibration, localization, ortho-rectification, object detection, coded targets, digital elevation modeling, geometric accuracy assessment, and cultural heritage. Short summaries of the accepted contributions are listed below in order of publishing date.

Nezhad et al. [1] investigated the problem of scanning line determination using push broom cameras, and developed a novel approach using a multi-layer perceptron (MLP)-based approach for determining the best scanning lines in a non-iterative manner. With the accelerated computing speed, this contribution is particularly relevant for real-time processing.

Burdziakowski [2] analyzed how scene illumination and the internal imaging processes such as color filtering and demosaicking, etc., are responsible for the feature localization and extraction used in the photogrammetric process. This is an important problem to investigate as it partially accounts for the varying performance of different sensors used in different scenes in the photogrammetric process. The article discusses the problem and concludes with recommendations and suggestions on the artificial lights and algorithms to be used for achieving the highest accuracy using photogrammetric methods.

Zhang et al. [3] investigated the problem of exterior orientation refinement, applied to the first Chinese airborne three-line scanner mapping system AMS-3000. Specifically, the authors introduced a Gaussian Markov EOP refinement method enhanced by cubic spline interpolation to mitigate stochastic jitter errors. Experimental comparisons with the piecewise polynomial model (PPM) and Lagrange interpolation model (LIM) demonstrate that this method is one of the best, achieving improvements of 50%, 45.1%, 29.9%, and 44.6% over the LIM, and 12.9%, 69.2%, 69.6%, and 49.3% over the PPM.

Li et al. [4] investigated the visual localization problems using monocular images and geo-referenced Google Street Views. This task is critical and challenging for many applications, such as autonomous navigation, virtual and augmented reality, and robotics, due to the dynamic and complex nature of urban environments that may obstruct Global Navigation Satellite System (GNSS) signals. The authors proposed a block-wise matching strategy to make use of semantic segmentation and image-level correspondences for query image indexing, and then consequently feature-based pose estimation. The authors show that the proposed method can achieve meter-level positioning accuracy and is robust to changes in acquisition conditions, such as image resolution, scene complexity, and the time of day.

Liebold et al. [5] investigated the problem of lens distortion correction of low-cost UAV cameras, which cannot be handled effectively by existing radial distortion models. This study presents a novel approach that divides the image sensor and distortion modeling into two concentric zones for the application of an extended radial lens distortion model. Practical tests revealed that the residuals of the bundle adjustment could be reduced by 63% with respect to the standard Brown model. On the basis of external reference measurements, an overall reduction in the residual errors of 40% was shown.

Hou et al. [6] investigated the problem of orienting and ortho-rectifying the Corona KH-4B panoramic images, which is a known issue due to its lack of geo-referencing information. The authors proposed a method called 2OC to address this problem, which is based on using generalized control information from reference images such as Google Earth orthophotos. The experimental results demonstrate that 2OC not only achieves automation but also attains a state-of-the-art level of generality and accuracy. The approach allows the use of historical data archives and has the potential to benefit various fields such as environmental remote sensing and archaeology.

Wang et al. [7] investigated the problem of small object detection in remote sensing images such as cars, ships, and airplanes. The authors argued that the typical methods are tied to specific rotations of the objects and they developed an approach that enables an arbitrary-oriented detection system through special data handling in their loss function design. They demonstrated that its performance on the UCAS-AOD, HRSC2016, and DLR-3K datasets is favorably fast and accurate.

Shang and Liu [8] investigated the problem of circular coded target (CCT) identification by focusing on the image preprocessing steps against complex illumination conditions. After identifying that the tuning the parameters of homomorphic filtering (HF) for eliminating the illumination is non-trivial, they proposed to use genetic algorithms to achieve automated parameter tuning. Their experiments showed that the proposed algorithm significantly improves the robustness and accuracy of CCT identification methods under complex lighting conditions, which helps to improve the quality and accuracy of photogrammetry and even helps to improve the decision making and planning process of photogrammetry.

Fuse and Imose [9] conducted a comparative study on the problem of digital elevation modeling (DEM) under the context of using sparse measurements from an altimeter, or under the context of seafloor modeling. Discrete cosine transform (DCT), DCT with elastic net, K-singular value decomposition (K-SVD), Fourier regularization, wavelet regularization, and total variation (TV) minimization were tested. The authors concluded that the K-SVD method is appropriate when the percentage of deficiencies is low, and that the TV minimization method is appropriate when the percentage of deficiencies is high. Based on these results, they developed a method integrating both methods and achieved an RMSE of 0.128 m.

Patias and Georgiadis [10] presented their project ENIGMA—Endorsing Safeguarding, Protection & Provenance Management of Cultural Heritage. This project aims to achieve excellence in the protection of cultural goods and artifacts from man-made threats by contributing to their identification, traceability, and provenance research, as well as by safeguarding and monitoring endangered heritage sites. The ENIGMA objectives were designed to help stakeholders more effectively respond to this complex and multidimensional problem and leverage active collaboration by fostering and enabling interlinking of databases, and evidence-based deployment of preventative measures.

Kocaman and Seiz [11] reviewed the role that photogrammetry plays in evaluating the geometric quality of satellite products in connection to the long-term monitoring of essential climate variables (ECVs). The authors analyzed the Global Climate Observing System (GCOS) implementation plan and the data quality requirements and explored various geometric quality aspects, such as internal and external accuracy and band-to-band registration assessment, for a number of satellite sensors commonly used for climate monitoring. The paper highlights that the geometric quality issues vary with the sensor, and regular monitoring of data quality and tuning of calibration parameters are essential for identifying and reducing the uncertainty in the derived climate observations. Fuse and Imose [9] conducted a comparative study on the problem of digital elevation modeling (DEM) under the context of using sparse measurements from an altimeter, or under the context of seafloor modeling. Discrete cosine transform (DCT), DCT with elastic net, K-singular value decomposition (K-SVD), Fourier regularization, wavelet regularization, and total variation (TV) minimization were tested. The authors concluded that the K-SVD method is appropriate when the percentage of deficiencies is low, and that the TV minimization method is appropriate when the percentage of deficiencies is high. Based on these results, they developed a method integrating both methods and achieved an RMSE of 0.128 m.

Conflicts of Interest: The authors declare no conflict of interest.

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