Conference Report: Optical 3-D Measurement Techniques

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The 2nd conference on Optical 3-D Measurement Techniques was held on October 4-8, 1993 at the Institute of Geodesy and Photogrammetry, Swiss Federal Institute of Technology (ETH), Zurich, Switzerland. This series of conferences is organized by Professor A. Gruen of the Institute of Geodesy and Photogrammetry, ETH Zurich, and Professor H. Kahmen of the Instutute of National Survey and Engineering Geodesy, University of Technology, Vienna, Austria. The conferences are held alternately at Vienna and Zurich. This year's meeting was organized in cooperation with ISPRS Commission V. FIG Commission 6, and the Swiss Society for Photogrammetry, Image Analysis, and Remote Sensing.

Prof. A. Gruen opening the conference.

The conference objective was to present recent developments in photogrammetric and geodetic measurement systems, emphasizing on optical 3-D static or kinematic applications in inspection, quality control, and robotics. The main aim was to bring together experts and users from universities, industry, government agencies, and engineering firms dealing with an array of related fields (photogrammetry, geodesy, surveying and machine-vision) and allow them to exchange information on recent scientific and technical advancements on the subject of optical 3-D measurement techniques. During the process, the participants were exposed to developments in fields relative to their expertise, which opens the possibility for innovative (often interdisciplinary) applications and mutual gains. The conference was attended by more than 150 participants from 25 countries.

To emphasize the broad and diverse range of applications, the keynote speech was given by Prof. Dr. R. Ernst, 1991 Nobel Laureate in Chemistry, on nuclear magnetic resonance Fourier transform spectroscopy. It was very interesting to see how theoretically different fields like photogrammetry and chemistry can be actually sharing objectives, approaches, and concepts.

The program included lectures by invited speakers, presented papers and poster sessions on algorithms, processing techniques, systems, hardware and software. Covered topics include surface reconstruction, sensor systems and calibration, feature extraction, matching and object reconstruction, automatic orientation, range images, and active triangulation. In addition, robot vision, target tracking, deformation and industrial measurement systems, and various applications were also discussed.

Several presentations focussed on *digital close range applications*, emphasizing the suitability of photogrammetric methods for the precise determination of shape changes during kinematic processes. Monitoring the effects of simulated earthquakes on walls through photogrammetry is a very good example. Digital photogrammetric systems for close range applications, employing digital cameras for image acquisition and digital photogrammetric techniques for online or near online processing appear to be gaining momentum. They offer the significant advantages of rapid data acquisition, operational flexibility, measurement accuracy, and reliability. However, there are also some inherent system limitations, with data storage and computer processing requirements being the major issues that can restrict the applicability of such systems. All these issues were addressed by an array of papers, focussing on whether the available data acquisition and processing standards can meet industry requirements.

Network design for accuracy optimization received large attention, mainly because of all the close range applications which deviate from the usual "60% overlap - 20% sidelap" air missions. Expert system approaches to network design appear to be

Prof. R. Ernst, Nobel Laureate, Chemistry 1991, delivering the keynote address.

quite promising. By taking into account specific project requirements, not only the network may be designed, but also a complete customized system, attempting to optimize both the geometric setup and the complete system configuration (including acquisition time, processing techniques, accuracy potential, data handling, etc.). Another notable trend was the importance of the integration/connection of CAD/CAM environments with such systems, which opens the potential for reverse engineering or quality control applications.

Successful applications of the combination of digital cameras with structured light, especially for *deformation measurements*, were also presented. However, the photogrammetric advancements for close range applications do not mean the end of all other approaches. Efficient systems for real-time monitoring of structure deformations using electronic tacheometry presented at the conference are valid non-photogrammetric alternatives.

Regarding *sensors and systems*, certain advancements on digital cameras have been made over the last years. Motorized focus digital cameras, complex vision systems for robot platforms, resolution improvement by combining sequentially recorded sub-images, calibrated zoom lens cameras and digital cameras used together with theodolites in video-theodolite systems were some of these advancements presented at the conference.

Examination of the *calibration and characterization* aspects of digital sensors provided confirmation of the very high quality of digital imagery. The characteristics of the available digital image capture systems can be safely assumed to meet photogrammetric expectations.

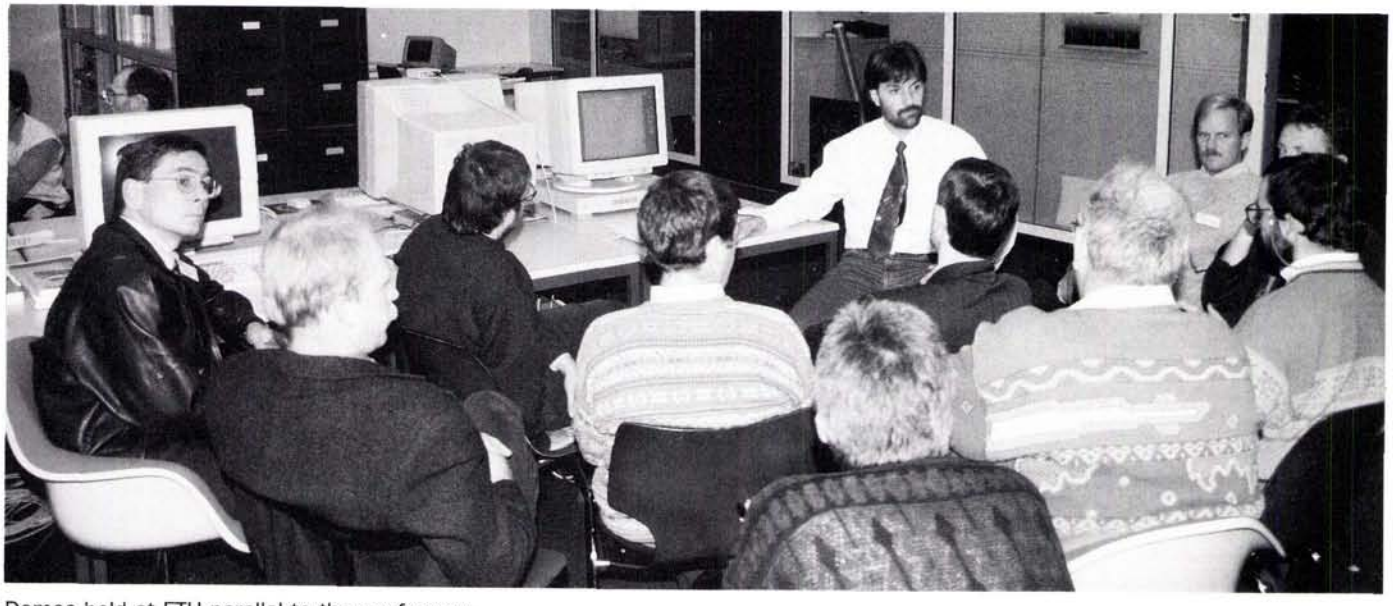
It was also rather interesting to see how even cheap, off-the-shelf systems (e.g., VHS camcorders) have the potential to be used in photogrammetric applications. This can have a great impact by broadening the application range of photogrammetric concepts to research fields that would have been otherwise turned off by the requirements for expensive dedicated digital cameras. However, there are still problems with the non-availability of CCD cameras of adequately large format which could be used for aerial photography. The conference confirmed the contradiction between constant developments in CCD cameras and the continuous inability to invade the market for aerial photogrammetric applications, while at the same time, other markets seem to be easier to access. Thus, even though digital techniques are accepted in close range/industrial applications, in aerial projects, the data capture part is non-digital (at the production level, at least) while digital applications typically proceed using digitized diapositives.

Digital photogrammetric systems for close range applications appear to be gaining momentum.

On *feature extraction and image measurement*, the accuracy potential of sub-pixel target and edge positioning was the main focus of presentations. On *matching*, some attempts to integrate object space information within the matching process were presented, though without significantly deviating from the existing approaches. As a major step, one could consider the expansion of least squares matching toward 3-dimensional volume elements, which is an example of photogrammetric progress via interdisciplinary applications. This application is dealing with the determination of velocity fields in flow tomography sequences. Both aspects of 3-D data capture and 3-D matching are quite challenging and interesting.

On the other hand, the marketability of digital photogrammetric techniques within the traditional photogrammetric community is also influencing research. For example (referring again to 2-D images), some efforts were presented toward automatic orientation of digital stereopairs, even though this could not be considered as a new technique, but rather a slightly modified implementation of concepts, algorithms, and strategies which have existed nearly five years already. Now that digital photogrammetric platforms are beginning to become available by photogrammetric manufacturers, the importance of automatic orientation is reevaluated. The catching-up of industry with research on digital photogrammetry is expected to have a rather large impact on future investigation topics, by dictating specific research directions within a broader, production-oriented scheme.

Other presentations that should be mentioned include the potential to use single-sensor vision metrology systems for industrial measurements, the integration of preformed spatial curves in ob-



Demos held at ETH parallel to the conference.

ject reconstruction, several experiments with the use of coded structured light for active aerotriangulation, as well as various robot vision applications and experiments with target tracking in a series of images.

Parallel to the conference, some demonstrations on various photogrammetric applications developed at ETH were presented by members of the Institute of Geodesy and Photogrammetry, ETH Zurich. The conference closed with a panel discussion, trying to evaluate the major trends identified in the presented papers.

From a photogrammetric standpoint, the conference presented many interesting applications and significant research advancements in digital photogrammetry. Despite these advancements, however, the transition from research and development to production appears to be slower than expected for digital photogrammetric systems.

As a result, and despite the gain in momentum of close range systems, commercial use is still quite limited. By putting photogrammetric applications in this conference, together with advancements in related sciences, the reasons for this gap were made more clear. It is obvious that the transition from analytical to digital photogrammetry is not as straightforward as the one from analog to analytical has been. Specifically, it does not consist of simple modifications in the method with which the (same) tasks are performed; but it also brings with it the evolution and eventual transformation of photogrammetry through the potential introduction of photogrammetric concepts, principles, and processes to traditionally nonphotogrammetric applications, as well as the introduction of nonphotogrammetric concepts and research principles to traditional photogrammetric processes.

The proceedings of the conference were published as a single, 624-page volume which can be purchased from Wichmann-Verlag, Postfach 4320, 76028 Karlsruhe, Germany; phone +0721 912200; fax +0721 9122020. The third conference on Optical 3-D Measurement Techniques will be held in two years in Vienna.