REPORT ON THE ACTIVITIES OF WORKING GROUP I/2 CAMERA CALIBRATION AND EFFECTS OF THE ENVIRONMENT

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ABSTRACT

The terms of reference, the intended work of the working group and the work carried out between September 1980 and March 1984 are reviewed.

INTRODUCTION

The present working group I/2 was formed after the Hamburg congress by combining the former two working group I/2 (Image Geometry with Camera Calibration) and I/3 (Image Properties with Environmental Factors). After several letters between from Prof. Dr. Trinder, the president of Commission I, and the authors, the following terms of reference were arrived at:

(1) To further investigate and compare methods of camera calibration to determine interior orientation parameters for radially symmetrical and decentring distortion.
(2) To further the studies of stability of elements of inner orientation, and the environmental conditions which affect the position of elements of inner orientation, image position and image quality.
(3) To determine methods of correcting geometric changes in image position introduced by changes in environmental conditions.
(4) To compare camera calibration and bundle adjustment with self-calibration with a view to deriving parameters for self-calibration from standardized calibration tests.
(5) To work towards standardization of the various elements defining the geometrical-optical performance of photogrammetric lenses.

Following closely these terms, we decided to organize five projects and suggested these in a first circular letter in March 1981 to former members of the two former working groups and some additional persons. Only a few responses were received; none of these suggested significant additions to the proposed program, nor a willingness to assume an active role in any of the projects. Therefore, the working group operates with a core of only a few persons and a large number of interested observers. This set-up has resulted in a somewhat slower than expected progress but has not prevented the five projects which will in the following be presented in more detail, from being carried out. Each project will be introduced in its description of March 1981 which will be followed by a review of the work actually carried out.

PROJECT 1 (COMPARISON OF CAMERA CALIBRATIONS)

"It is expected that this project will be completed within 1981. The programs for processing the accumulated data - some has still not been made available to NRC - will be ready soon. It is intended to make the final report available to all project participants prior to publication to accompanying the publication of the final report. This report and your statements related to it should provide a base for interesting discussions during the planned session (symposium) in Denver and during the symposium in Canberra".

A lengthy report [Ziemann 1982] introducing the intended goals of the project, describing the than current situation in regard to the input data, detailing the mathematical model developed for the reprocessing of all the different input data made available by project participants, indicating the process chosen for the reduction of the normal equations, and presenting data on the accuracy of image coordinate measurement and refinement, and radial lens distortion data was prepared in August 1982 for the German Research Foundation (DFG).

An extensive investigation was carried out in regard to the definition of average radial lens distortion data with odd-power polynomials based on all lens distortion reference curves ever included into the Canadian Specification for Aerial Survey Photography [Ziemann and El-Hakim 1982, 1983]. The results of this investigation were used as a base for the treatment of the rotationally symmetrical lens distortion in the project.

The processing of 198 calibrations for project 3 indicated that further changes to mathematical model and calibration procedure reported in the DFG-report were necessary. These changes will be reported in [Ziemann 1984b] together with recent results.

PROJECT 2 (EFFECTS OF ENVIRONMENTAL CONDITIONS ON THE ELEMENTS OF INTERIOR ORIENTATION)

"Investigations will be conducted into changes in focal length and distortion of photogrammetric lenses and cameras due to the effects of environments. Where possible, controlled environments will be simulated using operating cameras. Further tests under true aerial (or space) conditions will be correlated. A primary purpose will be to keep aerial surveyors informed of test results so that they can be informed of possible geometric errors".

Prior to and during the Hamburg congress results on the effects of environmental conditions were reported. Many cameras were subjected to temperatures as cold as -30°C during high altitude surveying, and [Meier 1978], [Bormann 1980] and [Norton 1980 a,b] have shown that the distortion of lenses and cameras changes significantly for this environment. It is suggested that photogrammetriest who operate under similar conditions - anything lower than -20° - monitor the temperature of their camera at five or more points (filters, outer lens, inner lens, focal plane, platen, etc) to determine from published data the magnitude of change in distortion.

Two paper on the subject of aerial camera vibration were published since the last congress: [Norton 1981] is a review of earlier work and its implication for the present, [Carman 1982] contains fairly recent data on vibration isolation characteristics of camera mounts.

It was planned to investigate the effects of pressure and extreme temperature on image geometry and quality. Encountered problems and obtained results will be reported in [Norton and Peck 1984].

PROJECT 3 (STABILITY OF PHOTOGRAMMETRIC CAMERAS)

"J. Hakkarainen suggests to evaluate data from repeated calibrations of the same cameras in view of changes of the calibrated focal length, symmetrical radial lens distortion, decentring distortion, distances between fiducial marks and resolving power. He will carry out annual calibrations of all cameras available in Finland until 1984 and asks for contributions from other institutions such as the National Research Council of Canada, the United

States Geological Survey and the camera manufacturers. It is hoped that NRC calibration plates for a larger number of cameras calibrated in 10 successive years can be located in storage and remeasured to provide most of the desired data. An attempt will be made to include those lenses known to have changed".

The problem of stability of mapping cameras has many aspects. The project was intended to provide data on the stability of lens/camera combination over a period of several yers as manifested by repeated recalibrations. Changes may occur as a result of normal handling or maintenance of a camera. Some results were reported in [Norton 1982], others are presented in two papers [Hakkarainen 1984a, Ziemann 1984a]. The investigation showed that aerial cameras in general can be considered quite stable but that changes do occur and should be guarded against.

It remains to investigate whether the observed changes are of significance for practical photogrammetric work. It appears in particular desirable to clarify the question of reference points in the centre of the photograph.

PROJECT 4 (CALIBRATION VS. SELF-CALIBRATION)

"NRC has available the measurements of three sets of simultaneously flown RC8/RMK réseau photography over three tests areas, and an as yet unmeasured st over a fourth test area, obtained within project 1. Each set consists of two 3x3 blocks with 60% overlap in both directions with a scale of approximately 1:5000, and 2 x 4 1:10 000 photographs over the center of these two blocks flown in four mutually perpendicular flight directions (e.g. W-E,, N-S, E-W, and S-N). NRC has also available a bundle adjustment program permitting the use of the majority of published sets of self-calibration parameters. It is therefore suggested that a study be undertaken to establish whether interior orientation parameters determined by a system calibration over a test field (lens distortion, film deformation) can be related to self-calibration parameters. Cooperation with WG III/1 (Identification and Elimination of Gross and Systematic Errors) is being sought in relation to this project".

Inclusion of this project caused some controversy with Commission III although contact was established with that commission at the earliest possible time with the aim of cooperation and separation of areas of interest. Since 1980 the interest in Commission III has become centred on gross-error detection.

Results of this investigation are reported in [Ziemann and El-Hakim 1984].

PROJECT 5 (STANDARDIZATION)

"W.P. Tayman has commenced a review of the "Recommended Procedures...". In addition, Hartmut Ziemann with the help of colleagues plans to prepare several papers reviewing various parameters defining the geometric-optical performance of photogrammetric lenses and cameras, primarily as a base for further discussions leading to suggestions for further standardization. Some of the planned papers should be available for the planned session/symposium in Denver, and for further discussion in Canberra".

A review of section 2 (Calibration) of the "Recommended Procedures..." was presented during the Annual Meeting of the American Society of Photogrammetry in 1982, and a revised version including suggestions made at that meeting at the Symposium in Canberra [Tayman and Ziemann 1982]. This report with minor modifications will be published in Photogrammetria. This review did not however, properly address visual calibration procedures and suggestions have recently been received see [Ziemann and Tayman 1984].

During a meeting in Salt Lake City in September 1983 it was decided that the issue of a further revision of the "Recommended Procedures..." be put to the National Reporters for Commission I, and that a special session be held during the Rio Congress to discuss these procedures and the proposal for ISPRS sponsored "Specifications for Vertical Aerial Photography" [Corten and Lorenz 1982]. The latter specifications were discussed in Enschede in December 1983 and revised in January 1984. A letter has been sent to the National Correspondents in April 1984 with the revised section 2 of the "Recommended Procedures..." noting that revisions to the remaining sections should aslo be made in particular in light of standardization efforts of the International Standards Organization. These efforts and other concerns are summarized in [Ziemann and Tayman 1984].

GENERAL COMMENTS

The work of the Working Group has been carried by few individuals; most are identified in the references. As a result, process has not been as fast as expected. The Working Group met during the meetings of the American Society of Photogrammetry in March 1982, in September 1983 and in March 1984. Few members were able to attend the symposium in Canberra. The September 1983 meeting was fortunate to see the President of ISPRS-Commission I, Prof. Dr. Trinder, amongst the participants, and was highlighted by a visit to the camera maintenance facilities and camera calibration at Hill Air Force Base in Utah.

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