REPORT ON ACTIVITIES OF WORKING GROUP III-2 IN 1980-84
(ON-LINE PHOTOGRAMMETRIC TRIANGULATION)
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INTRODUCTION

Resolution T.III/3 adopted at the 14th Congress of the International Society
for Photogrammetry and Remote Sensing (ISPRS) in Hamburg 1980 recommended to
continue studies of on-line photogrammetric·triangulation. Based on this
recommendation, the President of Commission III "Mathematical Analysis of
Data", Prof. Dr. E. Kilpela included the subject into his program of
Commission III activities and subsequently appointed the author of this
report as the Chairman of Working Group (WG) III-2 "On-Line Photogrammetric
Triangulation" (OLPT). In March 1981 the ISPRS Council approved the
nomination and a preliminary general outline of the program submitted by the
chairman. The working group superseded the 1976-80 group WG III-4.

As for the format of the working group, a consensus was found among the
members that WG III-2 should have the character of a study group. It was
agreed to concentrate on chosen subjects by conducting individual analyses,
simulations, practical tests and experiments as in a mission-oriented
research. A stiff organization of a uniform, closely controlled experiment,
with a distribution of identical material and binding procedures, was not
considered to be suitable for the time being.

PROGRAM

The WG III-2 program is generally aimed at the advancement of the on-line
technology for control extensions in those directions, in which its
advantages and superiority to off-line systems can be demonstrated. This is
currently feasible by improving methodology, organization and reliability of
photogrammetric triangulation. Consequently, three major groups of
activities are primarily considered:
- a further development of analytical formulations and of suitable recursive
  methods allowing for a dynamic least squares adjustment of data,
- studies of those operational aspects which can significantly reduce the
  volume of preparatory work and increase the cost effectiveness of
  triangulations,
- an efficient quality control of observed data by applying suitable blunder
  detection techniques based on rigorous statistical principles.

The group eventually reached a total of 26 active participants, of which five
represent manufacturers of analytical plotters. Based on the participants'
response, the originally proposed subject list was refined and extended into
the following outline of specific problems and technical details adopted for
our studies:

1. Formulations and Methods
    1.1. Suitable analytical formulations
    1.2. Use of additional parameters and constraints
    1.3. Recursive methods to update computations
    1.4. Image coordinate refinement
    1.5. Block adjustment in the host computer

2. Operational Aspects
   2.1. Computer controlled point transfer
   2.2. Refinement of program structures
   2.3. Suitable data banking and retrieval
   2.4. Organization of measurements
   2.5. Editing features
   2.6. Support of off-line methods
   2.7. Use of interactive graphics
   2.8. Operator-system interaction

3. Measurement Quality Control
   3.1. Computation feedback at critical phases
   3.2. Application of blunder detection techniques

Even though it is not a strictly enforced condition, practically all participants have an access to some on-line systems so that any theoretical and operational aspects studied could aslo be implemented and tested within the available system.

LIST OF ACTIVE MEMBERS AND THEIR AREAS OF INTEREST

Name	Country	System	Methodology 1.					Operational Aspects 2.								Quality Control 3.	
			1	2	3	4	5	1	2	3	4	5	6	7	8	1	2
BLAIS	Canada	Autoplot	+						+								
DORRER	W. Germany	Planicomp								+			+	+			
DOWIDEIT	Australia	AP C-3			+	+		+									+
ELASSAL	USA	NOSAP				+							+	+			
EL-HAKIM	Canada	Anaplot	+														+
FRASER	Canada	Autoplot	+														
GIRAUDIN	France	Traster	+		+					+						+	+
GRUEN	USA	Planicomp	+	+		+											+
HELAVA	USA	US-2						•	•	•	•	•	•	•	•	•	•
HOBBIE	W. Germany	Planicomp						•	•	•	•	•	•	•	•	•	•
HUYGHE	France	Traster						•	•	•	•	•	•	•	•	•	•
JAAKKOLA	Finland	DSR1								+							
JACOBSEN	W. Germany	Planicomp								+							+
JAKSIC	Canada	Anaplot							+				+				
KILPELA	Finland	DSR1	+														+
KRATKY	Canada	Anaplot		+				+	+	+	+	+	+			+	
KREILING	Switzerland	AC1, BC1							+	+	+			+			
LEUPIN	Canada	US-2							+			+	+	+			
LARSSON	Sweden	-----							+								
MARCKWARDT	E. Germany	Topocart		+	+				+								
RADWAN	Netherlands	APC-4	+		+												+
MOLENAAR	Netherlands	APC-4			+												+
SHARMA	India	Planicomp						•	•	•	•	•	•	•	•		
SLAMA	USA	NOSAP	+														
TURNER	USA	DSR1						•	•	•	•	•	•	•	•	•	•
YZERMAN	Italy	APC-4	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

Legend: + specific interest
         • general interest

MEETINGS

Most of the contacts with members were accomplished by circular letters and other mail. Nevertheless, two technical meetings were organized and gave opportunity to meet and discuss the WG III-2 topics:
- Commission III Symposium in Helsinki, June 1982
- WG III-2 OLPT Workshop in Ottawa, May 1983.

During these events business meetings of present members also took place. Another business meeting was attached to the 1983 ASP Annual Convention in Washington.

1982 Helsinki Symposium

The meeting was attended by 13 WG members and one and half sessions were available for on-line triangulation topics. All together nine papers were submitted and seven of them were presented (two colleagues were unable to come):

J.A.R. Blais: Recursive Least-Squares Estimation Using Givens Transformation

E. Dorrer, F.S. Kroell: Ergonomische Aspekte der On-Line Aerotriangulation

G.R. Dowideit: Experience with Improved On-Line Bundle Block Adjustment on the APC-3

A.A. Elassal: Generalized Adjustment by Least Squares

A. Gruen, A. Wyatt: An Optimum Algorithm for On-Line Triangulation

V. Kratky, S.F. El-Hakim: Quality Control for NRC On-Line Triangulation

V. Kratky: Recent Progress in the NRC On-Line Photogrammetric Triangulation

M.M. Radwan et al.: Triplets and Quadruplets in On-Line Photogrammetric Triangulation

H. Turner: The Canadian Marconi Aerial Triangulation Package

1983 Ottawa Workshop

A total of 11 members (4 from Canada, 4 from U.S.A. and 3 from Europe) participated in this event which provided an excellent opportunity to review the activities of individual members and to discuss the 1984 Congress. Special presentations and discussions covered both methodological and operational aspects of on-line triangulation. They included:

R. Blais: On the Use of Givens Transformations in Least Squares Computations

A. Elassal: An Evironment for the Utilization of Generalized Adjustment by Least Squares

M. Molenaar: Sequential Processing of Bundle Blocks

A. Gruen: Operational Aspects of the Triangular Factor Update in OLPT

V. Kratky: Efficiency of OLPT Operations

S. El-Hakim: On-Line Aspects of Data Snooping

H. Turner: Is Real-Time Versus Distributed Processing an Issue in OLPT?

PREPARATION OF THE 1984 CONGRESS

During the last business meeting at the Ottawa Workshop it was agreed on recommending to the President of Commission III that each of the two technical sessions assigned to WG III-2 at the 1984 Congress be introduced by

one Invited Paper whose title would agree with the theme of the session as follows:
    1. Algorithms and structures in on-line photogrammetric triangulation
    2. Operational aspects of on-line photogrammetric triangulation
Subsequently, the President has accepted our recommendation and nominated Dr. A. Gruen (USA) and Dr. E. Dorrer (W. Germany) as invited speakers for the above technical sessions. Each invited paper will be followed by three Presented Papers, to be selected from available submissions. The timing of all papers included in the program will allow for adequate discussions. Outside of the technical sessions about three to five presentations on on-line triangulation are expected to be accommodated in general poster sessions planned as a part of the technical program in Rio. At the time of preparing this report the chairman has received a total of 12 paper proposals related to our subject, from which the final program is to be prepared.

OVERVIEW OF ACHIEVEMENTS

During the reported period, on-line photogrammetric systems have been steadily expanding and, consequently, our WG members enjoyed much better hardware and software support than in previous years. This resulted in a broader and more active participation in our work. Based on the outcome of our meetings and discussions, as well as on the feedback received from individual members by correspondence, one can summarize the efforts and achievements of the working group as follows:

- Only a limited effort is reported to apply a full scale block adjustment directly on-line. It is acknowledged that on-line processes are geared towards streamlining and cleaning of collected data, thus allowing for a more efficient off-line block adjustment. Because of this combination of approaches, some of the refined features of the recent development of off-line methods are not being implemented directly during the on-line phase, e.g., additional image refining parameters.

- It is generally recognized that there are practical limits to a suitable subsystem within which to work on-line. The response time of the on-line system must conform to the conditions of a proper, economical interaction. Recursive updating methods contribute to higher speed and eficiency of on-line procedures only when a traditional formulation would result in appreciably longer computing times.

- For the first time we have also touched upon ergonomic aspects of on-line work judged in their direct effect on the performance and psychological adjustment of the operator. In this respect, especially computer graphics prove to be very useful. Graphical displays of any part of the on-line collected geometric information upgrade the interactive potential of triangulations in a very comprehensive form. It is recommended to persue this application in our future program.

- It was clearly documented that one of the most obvious benefits of the current state of on-line triangulation is the semi-automated coordinate transfer of tie points between models and strips. This technique has been sufficiently refined and tested to warrant its fast progress from experimental to full production applications.