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Presented Paper

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ISP - CORRELATION - TEST

Phase One Report

Abstract

At the Symposium of Commission II 1978 in Paris, the WG II-3 decided to invite all organizations being engaged in image correlation to a comparison. This test has to be performed by error analysis and detection of correlation failures based on height measurements in several standard models having different characteristics and a well-defined control. After a questionnaire action, the first four participants (later more) have delivered data of four models which are processed by IfAG, Frankfurt. The first experiences and results are reported.

Bibliography

[1] Lindig: Erste Erfahrungen mit dem ITEK-Korrelator EC-5, XIV. FIG-Congress, Washington 1974
(Ask for Engl. Transl.: Zeiss, D-7082 Oberkochen, Publ. No S 51-581)

[2] Lindig: Weitere Erfahrungen mit dem Itek-Korrelator EC-5, XIII. ISP-Congress, Helsinki 1976
(Ask for Engl. Transl.: Zeiss, D-7082 Oberkochen, Publ. No S 51-601e)

1. Introduction

On May 28, 1979 the Chairman of W.G. II-3 of ISP Commission II, Zarko Jaksic, sent the following invitation to 21 WG-members:

> "At its meeting held last September during the ISP Commission II Symposium in Paris, the Working Group II-3 on Automated Photogrammetric Instruments and Systems decided to organize a comparative test for image correlators. This program has been proposed by Dr. G. Lindig, of the Institut für Angewandte Geodäsie (IfAG), who also accepted an invitation to act as the coordinator of the program.
>
> The main objective of the first phase of the "ISP-Correlation Test" program is to establish basic criteria and to examine the methodology of testing procedures. Your cooperation in the program would be highly appreciated."

2. Task and methods

Attached to the invitation was a "Proposal" (see Annex 1) giving first information about task and method of the test. More details can be found in [1] and [2].

3. Participants

Another enclosure to the invitation was the questionnaire No 1 (Q 1), consisting of two parts, for the collection of information about potential participants in the test. For future use part A is attached as Annex 2 to this report. Part B asks the participants for their opinion about

- Output of co-ordinates
- Output medium
- Handling of correlation failures (gaps, operator helps)
- Demands for test-modes
- Publication of the results.

Within one month 8 positive and 3 negative reactions were received as reply to the invitation. Tab. 1 shows some data about the Testcenters and Tab. 2 about the systems and the participation terms according to Q 1.

4. Test models

Considering the demands of Part B of Q 1 for Phase One of ISP test, IfAG prepared four models and mailed them on July 27, 1979. Their specifications are shown in Annex 3, completed by the following characteristics.

Model 11 (very easy)
The large-scale photographs cover mainly steppe terrain with well distributed details for easy correlation. Some diffi-

No	Organisation	Place	State	WG-member	Abbr.
1	Defense Mapping Agency, Topographic Center	Washington	USA	Case	DMAHTC
2	Institut f. Photogrammetrie d. Universität	Hannover	FRG	Konecny	IPI
3	Institut f. Angewandte Geodäsie	Frankfurt	FRG	Lindig	IfAG
4	Topographical Survey Division, Surveys and Mappings	Ottawa	CAN	Allam	S&M
5	Dept. of Photogrammetry, University College	London	GB	Dowman	UCL
6	Jenoptik GmbH	Jena	GDR	Marckwardt	Jena
7	U.S. Geological Survey	Reston	USA	Starr	USGS
8	International Institute for Aerial Survey and Earth Sciences	Enschede	NL	Makarovic	ITC

Tab. 1 Test centers (Q1, Item 1)

No	System Name 2.1	Abbr. 2.1	2.3	2.4	2.5	3.1	3.2
1	Universal Automatic Map Compilation Equipment	UNAMACE	3	65	1		80
2	RASTAR	RASTAR	2	79	3	(yes)	80
3	Itek-Correlator/Planimat/Ecomat	EC-5	3	72	1	yes	79
4	Gestalt Photo Mapper System	GPM-II/3	3	77	3	yes	79
5	Epipolar Height Profiling System CPI-Plotter	EHPS	2	79	2	(yes)	80
6	Topomat/Coordimeter G	Topomat	3	76	2	yes	79
7	Gestalt Photo Mapper System	GPM-II	3	77	3	yes	79
8	Image maching b.m. of Compressed Digital Data	CDD	1	81	3		81

Tab. 2 Systems (Q1, Items 2 and 3)

culties may arise from new buildings which are relatively high with respect to the large photoscale. The greatest portion of the area is flat interrupted by some steeper slopes.

Model 12 (easy)
This model covers the same area as model 11 but at medium photoscale, so the buildings are now relatively smaller. The main difficulties can be experted from the very steep slopes at narrow, V-shaped valleys and some dark shadows.

Model 29 (mixed)
The small-scale photographs cover a cultivated area in Central Europe including some clearly limited woods with uniform heights of trees. The small parcelling of the fields enables good correlation but some difficulties may arise from the SWA-camera. The terrain is hilly with slopes which are not very steep.

Model 35 (difficult)
This large-scale model from northern Germany combines poor image quality with large fields making correlation in some parts very difficult or nearly impossible. This model was selected to discover expected differences in the capacity of the tested systems.

5. Test Instructions

In order to help the centers to get comparable and easy to handle test data, detailed (6 pages) instructions were distributed giving information about:

- Test material
- Inner orientation
- Relative orientation
- Absolute orientation
- Test point distances
- Test point sequence
- Registration
- Correlation failures (gaps)
- Time comparison
- Control data (check data).

6. Some problems

From the very beginning it was clear that in this first phase not all technical particularities of the different systems could be anticipated.

The centers 4 and 7 using GPM requested e.g. additional data for the preparatory part because no stereoscopical model is formed. As the beginning of the first profile was defined by the starting point (Annex 3) three auxiliar points (AP) had to be given for the definition of the end which could be used as control points, too.

Further problems arose from the not-existing model scale for GPM and the difficulty to identify some control points.

Two of the original six participants were not able to make their systems operational within the deadline (March 31,1980) of this congress report. The remaining centers 3, 4, 6, and 7 delivered their final test data to IfAG between Feb. 22 and March 10, 1980.

7. Test material

A complete set of material as it was sent to all centers consists of:

1 Test instruction
1 Model specifications (Annex 3)
4 Copies of pre-run information including ground control co-ordinates and other parameters
16 Sketches of control points
1 Form for Test Protocol
1 Guide for Gestalt Plotter
4 Lists of co-ordinates of APs
4 Sketches of APs
4 Enlargements for identification of APs
8 Duplicated negatives
4 Contact prints with marked control points.

8. Check data

In order to obtain data more or less free of errors for the calculation of the correlation accuracy careful manual scanning was carried out by different operators. The check data were arrived at by averaging the measurements of the skilled operators. Afterwards for all single scannings (including less skilled operators) standard deviations (SD = RMSE in Annex 4) were calculated with the program (FEKORR) used for the analysis of the correlator data.

Model	11		12		29				35			
Run	1		1		1		2		1		2	
Operator	SD	MAX	SD	MAX	SD	MAX	SD	MAX	SD	MAX	SD	MAX
1	3	40	4	-52	4	-62	4	42	8	-89	-	-
(2)	7	99	8	107	9	87	-	-	20	365	-	-
3	4	31	5	43	6	90	-	-	9	169	-	-
(4)	-	-	-	-	13	113	-	-	-	-	-	-
(5)	-	-	-	-	18	108	-	-	-	-	-	-
6	4	45	6	-81	7	-74	7	-87	13	-189	14	-323
7	4	36	4	44	5	55	-	-	8	227	-	-
8	4	-51	4	39	6	99	5	29	9	-285	9	225
Average	2		2		2				3			
N	5		5		8				7			

Tab. 3 Precision of Manual Scanning (mm/100 $\triangleq$ 0.033 $^{o}/_{oo}$ h)

From the results shown in Tab. 3 one can judge the later found accuracy of the correlation. If the accuracy of the dynamically acquired check data should be insufficient static measurements will be possible.

9. First results

Considering the short time available, nobody can expect extensive results and sophisticated analyses. The task of Phase One will be fulfilled when on the basis of preliminary results a conclusion can be drawn about the effectiveness of the method and when some comparable figures are obtained.

With respect to the accuracy of the system there is no problem to get objective information from the results of FEKORR as shown in Annex 4:

Systematic Errors (SE)	Mean Square Errors (MSE)
Reduced Mean Square Er.(RMSE)	Maximal Er. < 1.2 mm (MAXE)
Number of Gross Errors (NGE)	Maximal Gross Error (MAXGE)

Concerning the aspects of functionality and economy of the systems it is not so easy to get objective data, since not all the centers are able to interrupt the registration during correlation failures (Cor-Fails) delivering gaps in the data sequence. There exists such a possibility at the EC-5 which allows, using the Program ECPROK, by very simple means the objective analysis of the Cor-Fails. For all the other systems we have only the data of operator helps from the Test Protocols which are not always free of subjective influences.

The same problem exists for all systems when trying to compare their working speed. The data about the pure scanning time in the Test Protocols may perhaps be the only more or less comparable figures. After these remarks everybody may draw their own conclusions from the first results of ISP-Correlation-Test shown in Annex 4. A revised version of this table may be published at the congress.

10. Further activities

It is clear that after the positive termination of Phase One, another phase, let us say the "Main Phase of ISP-Correlation-Test" has to follow. Again all photogrammetrists engaged in image correlation are invited to participate in these tests. The more different systems are involved in the development of a kind of "Standard Test for Image Correlation" the more universal it will be at the end of that phase.

In continuing the work some questions have to be discussed too:

- Are four test models too many or too little and are they representative enough for all expected practical work?
- Can anybody offer better photographs to serve the purpose of a test model? Please contact the WG.
- Does any organization dispose of photos from a wooded area: once taken when covered by trees and a second time taken when trees are cut down? Please contact the address indicated on Annex 2.
- Which other enhancements of the method can be proposed?

As to the latter one a program extension is planned separating any desired model area for individual error analysis.

Annex 1

ISP COMMISSION II, WORKING GROUP II-3 ON
"AUTOMATED PHOTOGRAMMETRIC INSTRUMENTS AND SYSTEMS"

PROPOSAL FOR THE ISP-CORRELATION-TEST

OBJECTIVE: Evaluation of correlation systems

METHOD: Error analysis and detection of correlation failures based on height measurements in several standard models having different characteristics and a well-defined control. Information gathered through questionnaires will be used to determine the conditions for collection and preprocessing of data.

BACKGROUND: The correlation problems have been investigated for a number of years at the Institute for Applied Geodesy (IfAG). The results obtained by ITEK EC-5 correlators from more than 50 models, representative of various photographic and terrain conditions, have been analyzed. The stereopairs were scanned in Y-profiles with ΔX=8 mm spacing. The coordinates X,Y,Z have been recorded at intervals ΔY=2 mm on magnetic tape (9 track, 800 bpi, EBCDIC). The processing of collected data provided the following information:
- percentages of correlation failures;
- standard elevation errors.

For the determination of errors the mean elevations, derived from a number of manually measured profiles by different operators, have been used.

The IfAG is offering to provide the facilities and the personnel for the ISP-Correlation-Test.

PRESENTATION: Congress Report, Hamburg 1980

REMARK: The final Congress Report represents only the end of the first phase of the ISP Correlation Test. The goal of this phase is the evaluation of the methodology and the establishing of certain criteria. It is hoped that the test results will be used in the future by all organizations concerned with the development or application of correlation systems for in-house evaluation of their systems.

Annex 2

ISP-Correlation-Test
(WG II-3)

Date .....

Return to : Dr. G. Lindig
Weinbergstr. 9
D-6230 Frankfurt 80
Fed. Rep. of Germany

Questionnaire No. 1

General Part (A)

1. Organisation

   1.1 Name (Abbr.)

   1.2 Attention of

   1.3 Address

   1.4 Telephone 1.5 Telex

2. Correlation system

   2.1 Name

   2.2 Manufacturer

   2.3 Status

   1. Experimental ☐ , 2. Prototype ☐ , 3. Serial ☐

   2.4 Operational from 19..

   2.5 Type of System

   1. Analogue ☐ , 2. Hybrid ☐ , 3. Digital ☐

   2.6 Used for

   1. Orthophoto ☐ , 2. Contours ☐ , 3. DTM ☐ ,
   4. .....

3. Participation in the test

   3.1 now yes ☐ no ☐

   3.2 later yes ☐ from 19..

   3.3 If "no": Test material desired yes ☐
   also if charged yes ☐

4. Potential participants (others than in annexe)

   4.1 Name

   4.2 Attention of

   4.3 Address

   4.4 Telephone 4.5 Telex

5. Remarks

Model specifications

	1	2	3	4
No. of Model	11	12	29	35
Type of Terrain	Steppe w. Buildings	Steppe	Fields w. Woods	Fields
Woods %	-	-	20	10
Buildings %	30	10	10	-
Height differences m	210	210	292	114
Average slope tan	0.05	0.09	0.06	0.10
Camera	WA	WA	SWA	WA
Focal length mm	153.34	153.34	88.54	152.55
Photo scale 1:	15 000	28 000	65 000	12 000
Model scale 1:	7 500	14 000	32 500	6 000
bx mm	172.00	190.00	170.00	170.00
Photo No. left	1111	8912	1220	779
Photo No. right	1110	8914	1221	781
Number of Profiles	24	26	20	28
Model limits: left x	29900	29900	29900	29900
right x	49300	50900	46100	52500
lower y	28900	29100	29800	22400
upper y	68500	69300	66100	58600
Test points	4750	5200	3600	4730
Starting point	9	17	109	85
Control points	10,11,12	18,19,20	110,111, 112	86,87,88
Auxiliar points	100,101, 102	180,181, 182	1101,1100, 1102	860,861, 862

Results of ISP-Correlation-Test, Phase One

Model No.	Center	Version	Profiles	Height errors mm/100 ≙ 0.033 ‰ h						Operat.Helps	Number of Gaps						Scan Time
											Length in mm				Total		
				SE	MSE	RMSE	MAXE	NGE	MAXGE		4	6	8	10	No.	%	min.
11	3	33	24	6	18	16	120	6	-161		24	9	4	3	43	2	45
		33I	"	6	18	16	120	5	-161					3	6	0	
		34	"	-2	13	13	120	9	-155	0					0		35
	4	01	24	-10	20	17	120	14	-173	10					0		46
		02	"	-4	16	16	120	12	-171	13					0		52
	6	00	24	-16	23	16	117	7	-152	1					0		23
	7	01	24	-5	13	11	119	11	-156	10					0		32
		02	"	-6	13	11	112	8	-155	10					0		41
12	3	30	26	3	19	18	120	15	270		26	1	0	0	27	1	50
		30I	"	3	19	18	120	17	270						0	0	
		31	"	-1	12	12	114	10	246	4					0		50
	4	01	25	0	12	12	99	6	-158	17					0		48
		02	"	-4	13	12	106	3	-164	14					0		43
	6	00	26	-1	15	15	120	19	-430	3					0		26
	7	01	26	8	13	10	103	1	156	12					0		33
		02	"	2	10	9	111	0		30					0		30
29	3	33	20	7	19	17	117	9	203		8	0	1	0	9	0	20
		33I	"	8	19	18	117	9	203						0	0	
		34	"	1	20	19	112	7	-191	2					0		30
	4	01	20	7	14	12	99	0		22					0		51
		02	"	-10	40	39	120	96	-222	28					0		57
	6	00	20	9	26	24	120	37	431	0					0		18
	7	01	20	11	15	10	100	0		25					0		38
		02	"	9	13	10	119	0		50					0		69
35	3	33	28	0	33	33	120	108	410		17	5	1	0	24	0	30
		33I	"	0	34	34	120	113	410						1	0	
		34	"	0	34	34	120	314	449	18					0		35
	4	01	25	-18	28	21	120	47	-337	47					0		60
		02	28	-17	29	23	120	75	-326	51					0		65
	6	00	26	7	32	31	120	297	744	0					0		23
	7	01	28	2	26	26	119	70	482	75					0		47
		02	28	4	21	20	120	39	585	59					0		50

	3	30	Max.scan speed = 10 mm/sec, small raster, with gaps on tape
		31	" , " , no gaps, only comparable
		33	" , large raster, with gaps on tape
		34	" , " , no gaps, only comparable
	4	01	GPM-II/3, scan in model co-ordinate system
		02	" , scan in ground co-ord. system ≙ right photo system
	6	00	Scan speed = 10 mm/sec (in model scale)
	7	01	GPM-II/1
		02	GPM-II/2

..I = Gaps of 4, 6 and 8 mm length linear interpolated