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Correlation of Paddy Field for Land Boundary Record

TS 10K – Cadastral Boundary Issues

Dr Conrad TANG and Dr Y L GUAN

The Hong Kong Polytechnic University
Department of Land Surveying & Geo-Informatics

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1. Introduction

1) Demarcation District Sheets (DD sheets)
- Cadastral survey plans produced between 1899 and 1903 in New Territories
- To identify land ownership and to access Crown rents
- No coordinate reference information
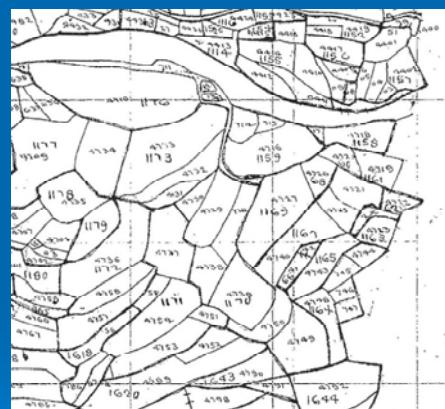
DD 106 (portion)   Aerial Photo 1963

Scale : 1:3960   5-chain grids

Survey Sheet 1968   Aerial Photo 1963
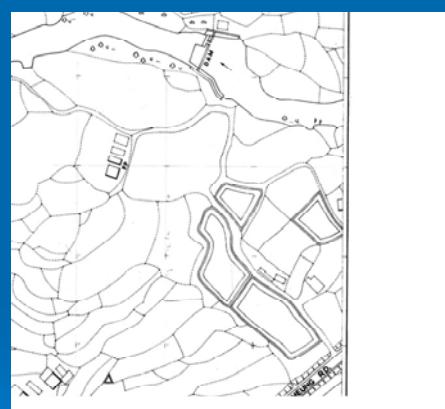
al Photo 1963

Methods of correlation

- Only the subject lot is correlated onto the coordinated survey plan at an arbitrary best-fit location;
- Subject lot and surrounding lots are correlated with a best mean fit using DD sheets and survey sheets;
- Correlation exercises are performed between DD sheet and orthophoto

Correlation exercise

aerial photo

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2. Technical Scheme

- digital photogrammetry (Leica LPS)

- data:

  1963 aerial photos & DD Sheet

  scanning resolution: 1200 dpi

- KGPS survey for control points using HK
  Satellite Positioning Reference Station Network

Flowchart of DD sheet geo-referencing
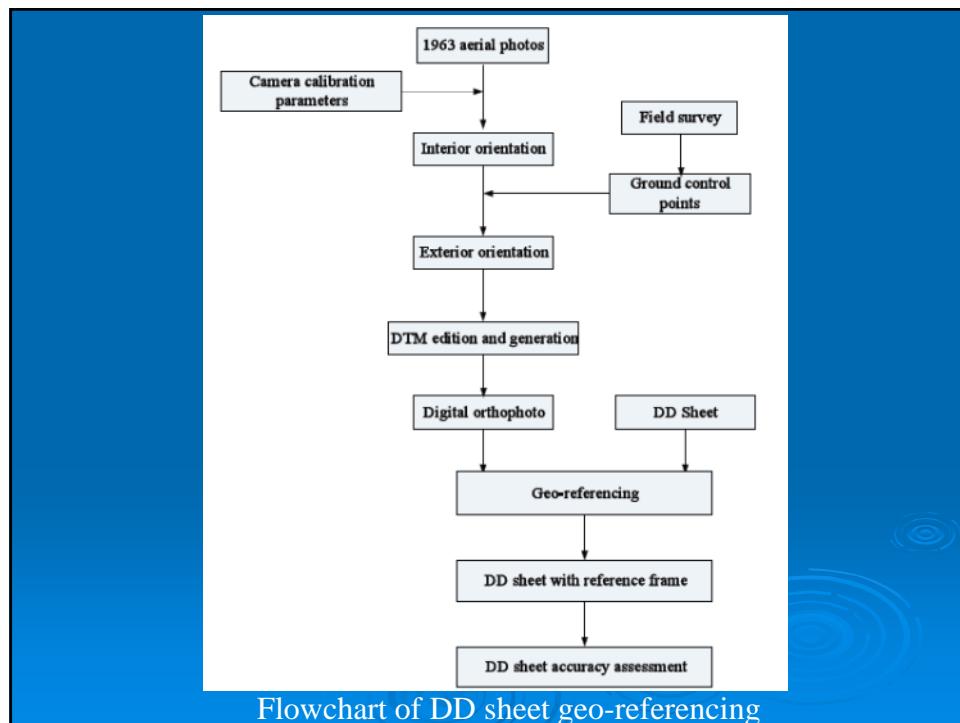
generation of orthophoto

Field reconnaissance and survey

- old well are taken as control points
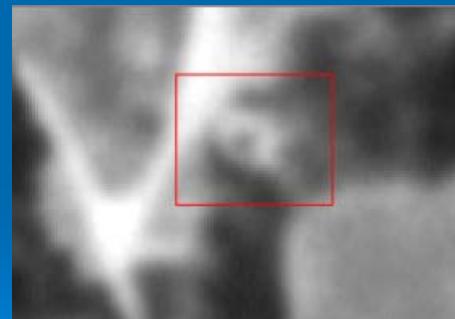
A well on 1963 aerial photograph and its corresponding position now
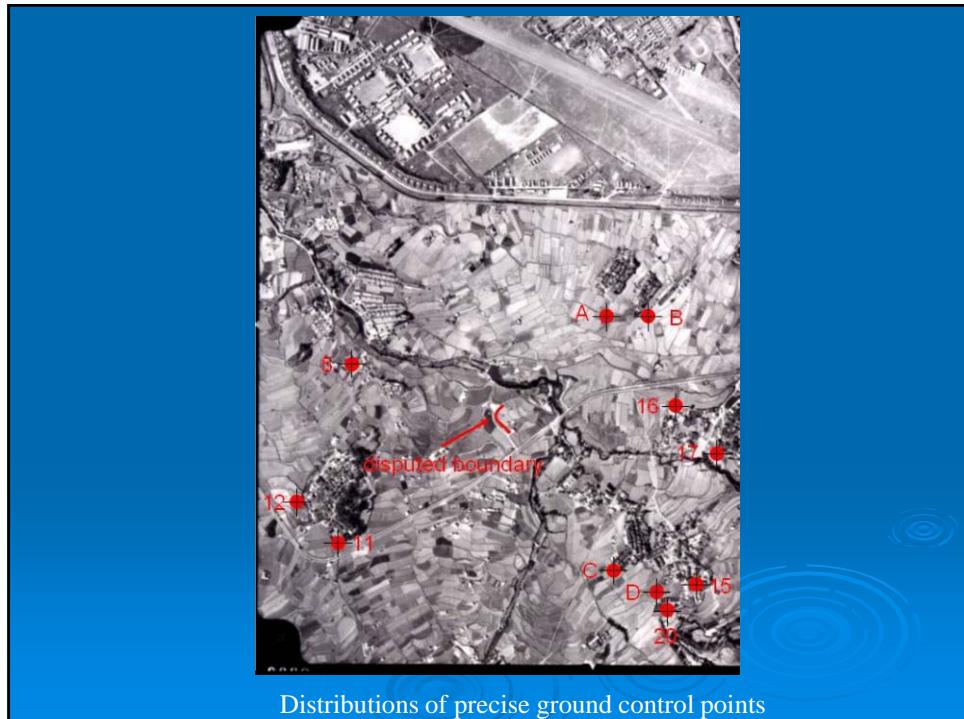
Distributions of precise ground control points

Interior orientation (IO)

Problem:
Camera original calibration information was not available

Approximation:
Adopt standard IO parameters of camera model (Wild RC8)

Tested IO Errors are 0.48 pixels and 0.43 pixels respectively; equivalent to 10.86μm and 9.77μm.

Exterior orientation
- aerial triangulation
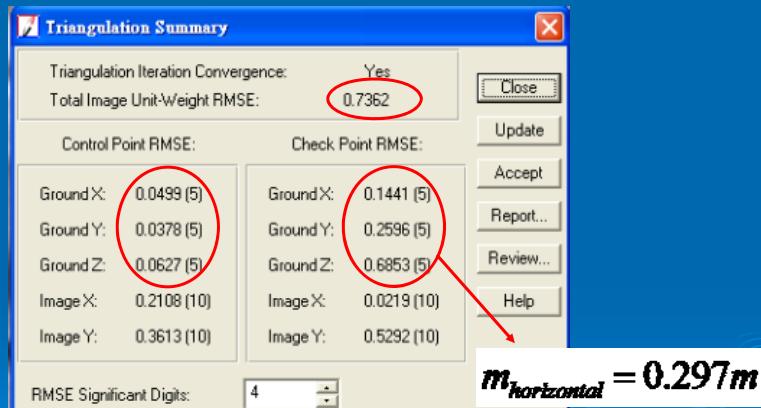
Aerial triangulation results

Generation of stereo model and orthophoto

Image pair with correct position $\longrightarrow$ stereo model

DTM $\xrightarrow{\text{Differential rectification}}$ Orthophoto

Point measurement on stereo model

Point measurement on digital orthophoto
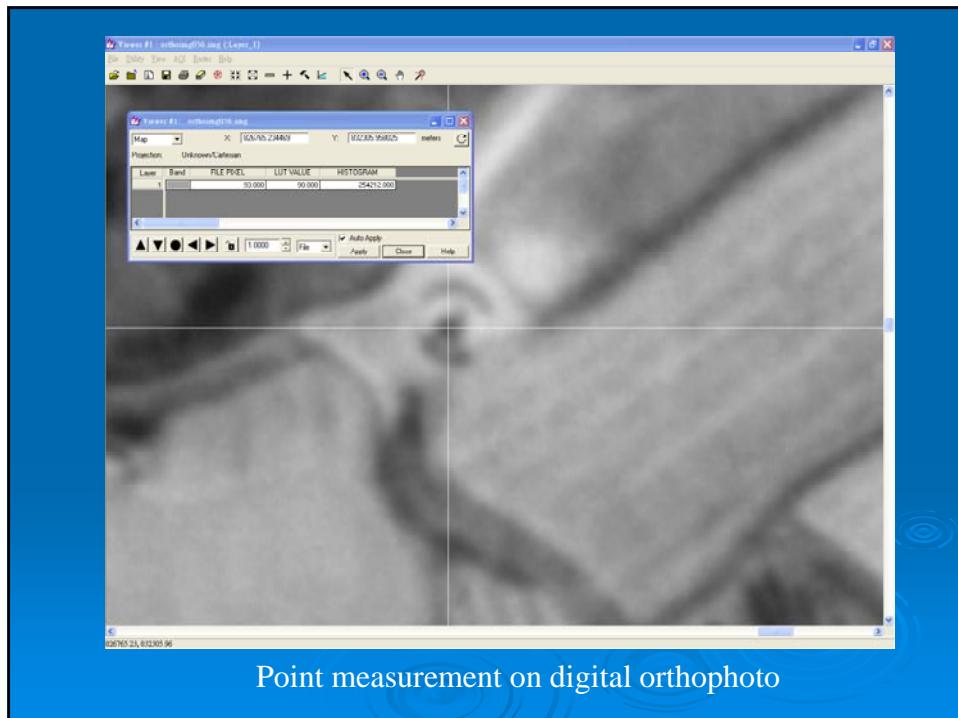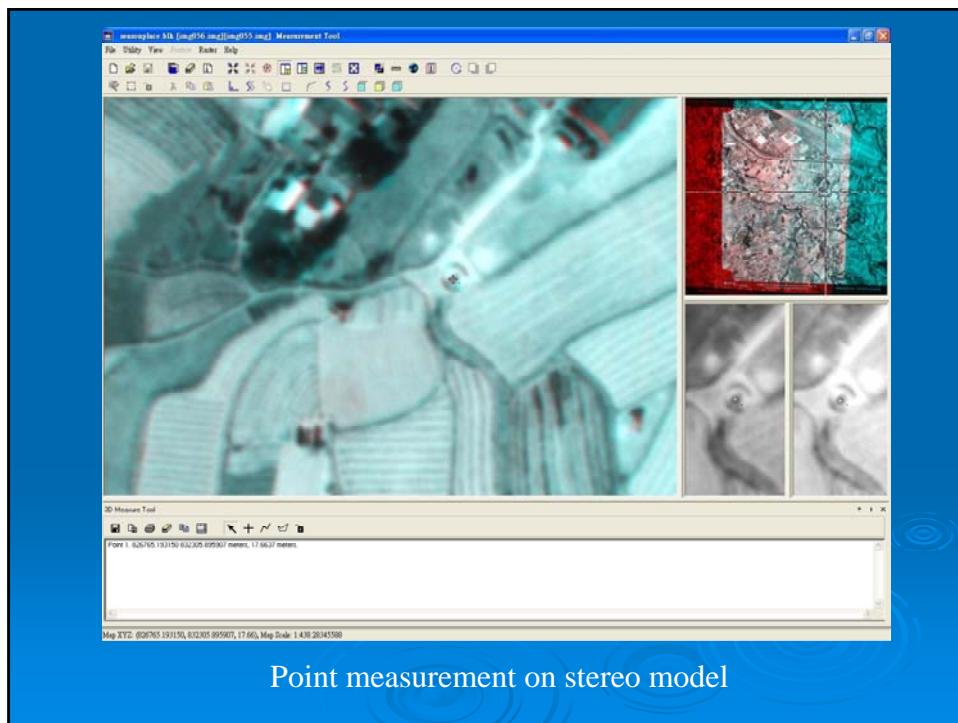
Field bund junction points for geo-referencing
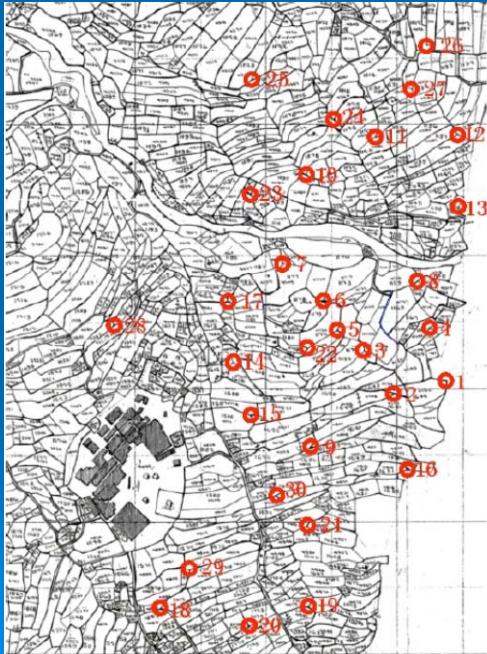
A point on DD sheet and on orthophoto

Geo-referencing operation

- affine transformation

$$x = a_0 + a_1 x' + a_2 y'$$
$$y = b_0 + b_1 x' + b_2 y'$$

x, y point coordinate in orthophoto

x', y' corresponding position on DD sheet

- positional accuracy

$$RMSE = \sqrt{\frac{\left(x_{measured} - x_{transform}\right)^2 + \left(y_{measured} - y_{transformed}\right)^2}{n}}$$

n---the number of check points

Table 1 Position error of check points in scheme 1 (unit: metre)

| NO	orthophoto		Rectified DD sheet		Difference		RMS	remark
	X	Y	X	Y	X	Y		
1	826473.2	831925.4	826471.2	831925.0	2.0	0.4	2.0	CPs
2	826390.6	831903.4	826389.9	831906.0	0.7	-2.6	2.7	
3	826347.1	831969.0						GCPs
4	826447.2	832004.5						
5	826305.1	831998.6	826306.6	832000.8	-1.5	-2.2	2.7	CPs
6	826286.3	832046.3						GCPs
7	826225.0	832101.0	826225.7	832102.7	-0.7	-1.7	1.8	CPs
8	826430.2	832075.8						GCPs
9	826264.2	831824.0	826260.3	831823.6	3.9	0.4	3.9	CPs
10	826260.8	832238.3	826265.5	832237.9	-4.7	0.4	4.7	(Check
11	826365.1	832295.3	826372.2	832295.3	-7.1	0	7.1	Points)
12	826490.5	832301.0	826498.0	832298.7	-7.5	2.3	7.8	
13	826492.0	832189.8	826496.7	832189.8	-4.7	0	4.7	
14	826145.1	831950.7	826146.1	831954.5	-1.0	-3.8	3.9	
15	826174.9	831871.9	826171.5	831872.7	3.4	-0.8	3.5	
16	826415.2	831786.9	826408.5	831790.6	6.7	-3.7	7.7	
17	826134.2	832045.5	826140.5	832046.1	-6.3	-0.6	6.3	
18	826030.2	831575.4	826025.3	831578.5	4.9	-3.1	5.8	
19	826262.3	831579.7	826250.3	831580.8	12.0	-1.1	12.1	
20	826170.2	831549.5	826159.3	831551.1	10.9	-1.6	11.0	
21	826261.2	831702.7	826252.3	831703.5	8.9	-0.8	8.9	
22	826261.4	831971.5	826260.4	831974.0	1.0	-2.5	2.7	
23	826168.5	832206.0	826179.6	832207.9	-11.1	-1.9	11.3	
24	826304.5	832324.5	826310.1	832322.4	-5.6	2.1	6.0	
25	826173.7	832378.3	826185.0	832383.2	-11.3	-4.9	12.3	
26	826442.6	832438.8	826454.4	832435.4	-11.8	3.4	12.3	
27	826424.7	832366.0	826430.0	832368.3	-5.3	-2.3	5.8	
28	825958.4	832011.0	825965.3	832009.5	-6.9	1.5	7.1	
29	826080.5	831637.8	826071.1	831637.9	9.4	-0.1	9.4	
30	826218.0	831751.5	826206.6	831750.2	11.4	1.3	11.5	
Position error			x		7.2			
			y			2.2		
			horizontal				7.5	

positional error distribution

overlaying geo-referenced DD sheet with orthophoto

correction:moving left

Systematic error effects

Correction:moving right
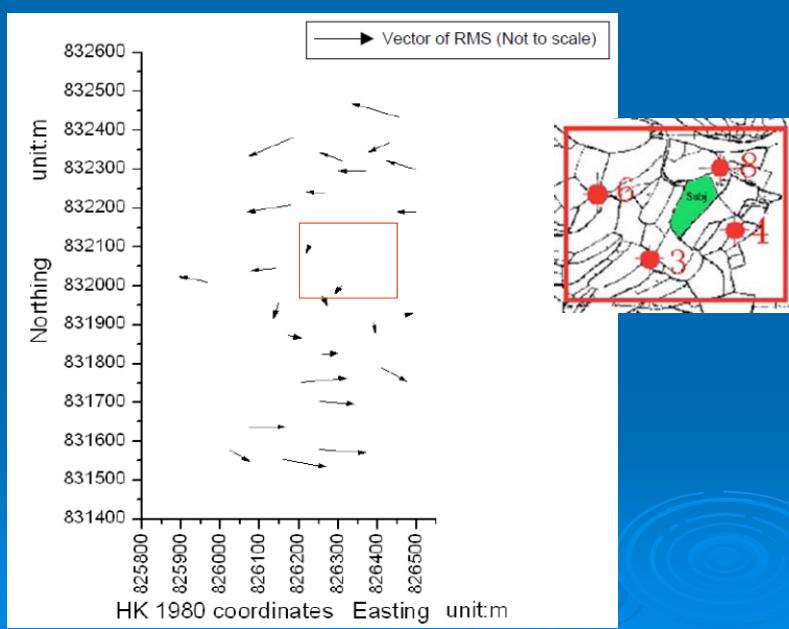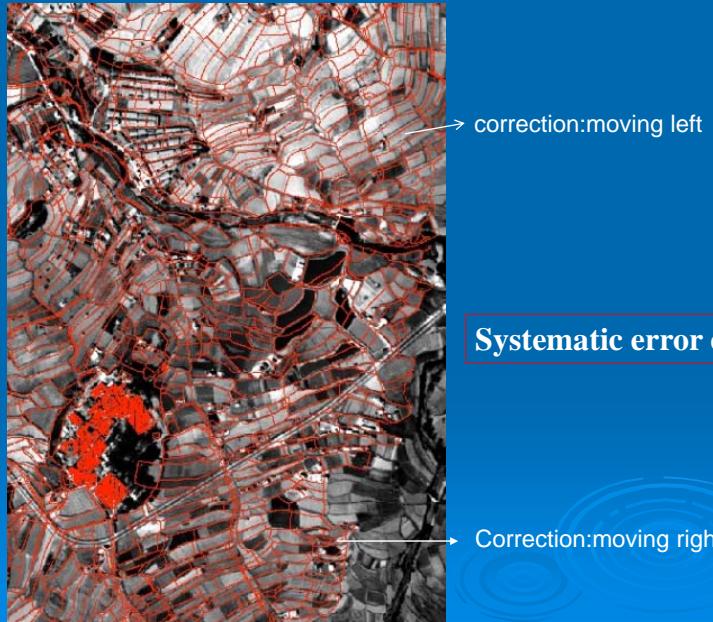
● Scheme 2

control area:
About
400m x 500m

Geo-referencing result

Link Table

Link	X Source	Y Source	X Map	Y Map	Residual
1	4.574606	7.385332	826260.800000	832238.300000	0.32524
2	6.876781	6.910872	826492.000000	832189.800000	0.30076
3	6.110028	2.947444	826415.100000	831786.900000	0.28140
4	3.723464	3.769090	826174.900000	831871.800000	0.30587

Point 10
Point 13
Point 16
Point 15

☑ Auto Adjust   Transformation: 1st Order Polynomial (Al ▼   Total RMS Error: 0.30372

Load...   Save...   Restore From Dataset   OK

Table 2 Position error of check points in scheme 2 (unit: metre)

NO	orthophoto		Rectified DD sheet		difference		RMS	Remark
	X	Y	X	Y	X	Y		
1	826473.2	831925.4	826473.2	831923.6	0	1.8	1.8	
2	826390.6	831903.4	826393.7	831903.8	-3.2	-0.4	3.2	
3	826347.1	831969.0	826349.0	831967.5	-1.9	1.5	2.4	
4	826447.2	832004.5	826448.2	832003.6	-1	0.9	1.3	Check
5	826305.0	831998.6	826307.8	832000.1	-2.8	-1.5	3.2	points
6	826286.3	832046.3	826286.8	832044.8	-0.5	1.5	1.6	(CPs)
7	826225.0	832101.0	826224.4	832102.9	0.6	-1.9	2.0	
8	826430.2	832075.8	826429.3	832075.0	0.9	0.8	1.2	
9	826264.2	831824.0	826266.7	831821.4	-2.5	2.6	3.6	
10	826260.8	832238.3						GCPs
11	826365.1	832295.3	826365.4	832296.6	-0.3	-1.3	1.3	CPs
12	826490.5	832301.0	826490.4	832300.2	0.1	0.8	0.8	
13	826492.0	832189.8						GCPs
14	826145.1	831950.7	826149.4	831952.9	-4.3	-2.2	4.8	CPs
15	826174.9	831871.8						GCPs
16	826415.1	831786.9						
17	826134.2	832045.5	826140.6	832045.2	-6.4	0.3	6.4	CPs
18	826030.2	831575.4	826038.0	831573.8	-7.8	1.6	8.0	
19	826262.3	831579.7	826263.3	831576.3	-1.0	3.4	3.5	
20	826170.1	831549.5	826173.4	831546.7	-3.3	2.8	4.3	
21	826261.2	831702.7	826261.8	831700.4	-0.6	2.3	2.4	
22	826261.4	831971.5	826262.7	831972.2	-1.3	-0.7	1.5	
23	826168.5	832206.0	826176.1	832209.0	-7.6	-3.0	8.2	
24	826304.5	832324.5	826302.8	832323.6	1.7	0.9	1.9	
25	826173.7	832378.3	826177.0	832385.2	-3.3	-6.9	7.6	
26	826442.6	832438.8	826443.9	832437.1	-1.3	1.7	2.1	
27	826424.7	832366.0	826421.4	832369.8	3.3	-3.8	5.0	
28	825958.4	832011.0	825967.4	832008.3	-9.0	2.7	9.4	
29	826080.5	831637.8	826083.8	831634.1	-3.3	3.7	5.0	
30	826218.0	831751.5	826215.0	831747.4	3.0	4.1	5.1	
RMS			X		3.67			
			Y			2.55		
			horizontal				4.47	

Interpolation accuracy:
2.0 m

positional error distribution
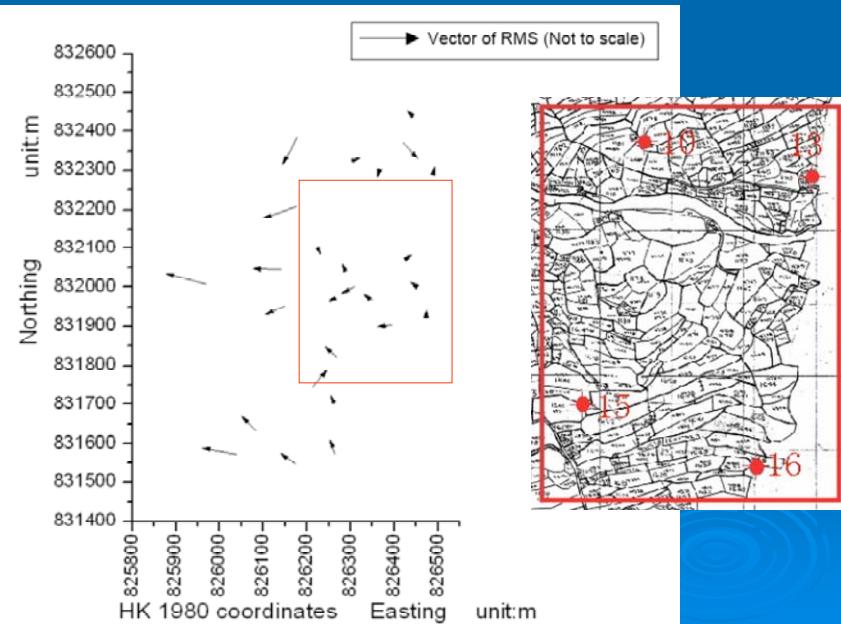
Overlaying geo-referenced DD sheet with orthophoto
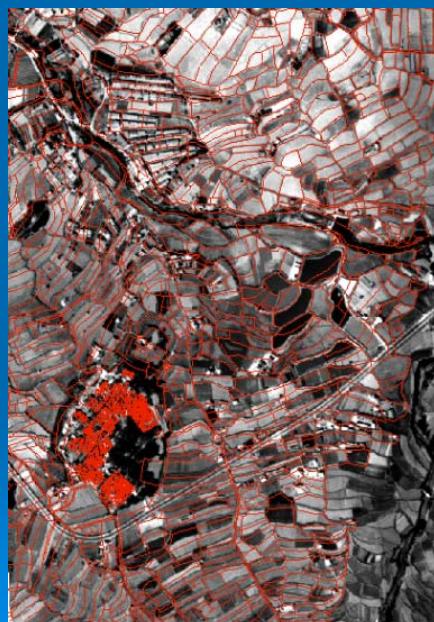
Interpolation of coordinated image is always a preference to extrapolation

comparison of two schemes

Scheme 1 : extrapolation
Scheme 2 : interpolation & extrapolation

Table 3 accuracy statistic comparison (unit: metre)

No.	X direction error			Y direction error			RMS
	maximum	Minimum	RMS	maximum	minimum	RMS	
Scheme1	12.0	0.7	7.2	4.9	0.1	2.2	7.5
Scheme2	9.0	0.0	3.7	6.9	0.3	2.6	4.5

4. Conclusions

● The accuracy of the ortho-images – 0.3 m

● The DD sheet has a localized error pattern

● The correlation of DD & the 1963 ortho-photo gives an *interpolation* result in a small area (200 m by 200 m) about 2-metre accuracy

● The extrapolation results are not recommended

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Thank you!