Precise Agriculture Lot Boundary
Determined by Photogrammetric Modeling

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Introduction

Land boundary determination in the New Territories of Hong Kong

In the New Territories, the Demarcation District (DD) sheets are still in use as the legal record of land boundaries.
- DD sheet: have no coordinates framework

- Limited by the graphic accuracy e.g. 16”DD with only a positional accuracy of 4 m by itself.

- Extrinsic evidence of aerial photos e.g. 1949 and 1963
- Aerial photo: show the features of the time.

- From the 60’s photo, field bounds largely maintained as in 1905

- Determine agricultural lot boundaries by digital photogrammetry
Digital Photogrammetry

Exterior Orientation

1) Geo-referencing old survey sheet, then collect control-point coordinate information

2) Field Survey using Kinematic GPS method, collect control-point coordinate information.
Data resources

- 1960, 67, 73 old survey sheet (Yuen Long)

- 1963 aerial photo (Yuen Long, scanned with 1200dpi)

- 2008 Survey Sheet (Yuen Long)
Software adopted

ArcGIS 9.2

Leica Photogrammetry Suite 9.2

In all these experiments, software processing:
X means Easting;
Y means Northing;
1963 Aerial Photos

Camera Calibration Parameters

Interior Orientation

Georeferencing Old Survey Sheet/Field Survey

Ground Control Points

Exterior Orientation

Stereo Model

DTM

DOM

Boundary Measurement

Overlay and Comparison

1:1000 Survey Sheet & Lot Index Plan
Coordinate Transformation

Old Imperial

Nothing +50,000ft ; Easting +120,000ft

New Imperial

Feet to meter *0.3048 ;
A constant of (-3550) is added to Easting

Metric

Northing +800,000m ; Easting +800,000m

1980 Datum (Current)

Local datum error may exist !
Georeferencing Old Survey Sheet

Here, coordinate transformation is needed

Add Control Point:
Coordinate information should be inputted
Then, the old survey sheet can provide features’ coordinate information
Field Work for control points in exterior orientation

- Adopt wells as the top priority ground control point

Sensible to believe:
Old wells may be in-use, covered or filled, but their location can be determined accurately
Well in aerial photo (63)
Well in old survey sheet (73)
Well in lot index plan (2011)
● Kinematic GPS

● Centimeter level
# Models with Different Control Points

<table>
<thead>
<tr>
<th>Model Name</th>
<th>GCP Period</th>
<th>GCP Coordinate Source</th>
<th>GCP Type</th>
<th>Number of Control</th>
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</thead>
<tbody>
<tr>
<td>Model 60 field-bund</td>
<td>1960</td>
<td>Old Survey Sheet Capture</td>
<td>field-bund Crossing</td>
<td>27</td>
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<tr>
<td>Model 67 field-bund</td>
<td>1967</td>
<td>Old Survey Sheet Capture</td>
<td>field-bund Crossing</td>
<td>24</td>
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<tr>
<td>Model 73 field-bund</td>
<td>1973</td>
<td>Old Survey Sheet Capture</td>
<td>field-bund Crossing</td>
<td>25</td>
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<tr>
<td>Model 73 field-bund *</td>
<td>1973</td>
<td>Old Survey Sheet Capture</td>
<td>field-bund Crossing</td>
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<td>Model 73 Well</td>
<td>1973</td>
<td>Old Survey Sheet Capture</td>
<td>Old Well</td>
<td>4</td>
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<tr>
<td>Model 2009 Well</td>
<td>2009</td>
<td>RTK Field Collection</td>
<td>Old Well</td>
<td>5</td>
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</tbody>
</table>
Control Point Distribution

Exterior Orientation using field-bund crossings

Field-bund
Control Point Distribution

Exterior Orientation using old wells (still exist, 2009)

Model 73 Well

Model 09 Well
Exterior Orientation in LPS

Model 60 field-bund

-- Triangulation Summary (60)

Based on the 60’ survey sheet

Control/Check Point
Type: “Y”/”T” field-bund crossing
Unit: Meter —Ground
Unit: Pixel –Image

\[ M_{\text{horizontal}} = 1.15 \text{m} \]
Product: DOM 1960 field-bund

Accuracy can achieved
Application:

Overlap comparison:
1960DOM(field-bund) & 2008SurveySheet(1:1000)

Overlap comparison:
1960DOM(field-bund) & 1960SurveySheet(1:1200)
Exterior Orientation in LPS

--- Triangulation Summary (67)

Based on the 67’ survey sheet

Control/Check Point
Type: “Y”/”T” field-bund crossing

Unit: Meter —Ground
Unit: Pixel —Image

\[ M_{\text{horizontal}} = 1.28 \text{m} \]
Product: DOM 1967 field-bund

Accuracy can be achieved.
Overlap comparison:
1967DOM(field-bund) &
2008SurveySheet(1:1000)

Overlap comparison:
1967DOM(field-bund) &
1967SurveySheet(1:1200)
Exterior Orientation in LPS

Model 73 field-bund -- Triangulation Summary (73)

Based on the 73’ survey sheet

Control/Check Point
Type: “Y”/”T” field-bund crossing

Unit: Meter —Ground
Unit: Pixel —Image

\[ M_{\text{horizontal}} = 1.22 \text{m} \]
Product: DOM 1973 field-bund

Accuracy can be achieved
Overlap comparison:
1973DOM(field-bund) & 2008SurveySheet(1:1000)

Overlap comparison:
1973DOM(field-bund) & 1973SurveySheet(1:1200)
Exterior Orientation in LPS
-- Triangulation Summary (73)

Model 73 well

Based on the 73’ survey sheet

Control/Check Point
Type: Old well
Unit: Meter —Ground
Unit: Pixel —Image

$M_{\text{horizontal}} = 1.08\text{m}$
Product: DOM 1973 well

Accuracy can achieved
Overlap comparison:
1973DOM(well) &
2008SurveySheet(1:1000)

Overlap comparison:
1973DOM(well) &
1973SurveySheet(1:1200)
Exterior Orientation in LPS

-- Triangulation Summary (73)

Based on the 73′ survey sheet

Control/Check Point
Type: “Y”/”T” field-bund crossing

Unit: Meter —Ground
Unit: Pixel –Image

\[ M_{\text{horizontal}} = 2.75 \text{m} \]
Exterior Orientation in LPS

-- Triangulation Summary (2009)

RTK technique is used to acquire the coordinate of control point (2009)

Control/Check Point
Type: Old well
Unit: Meter —Ground
Unit: Pixel —Image

\[ M_{horizontal} = 0.30m \]
Product: DOM 2009 well

Accuracy can achieved
Overlap comparison:
2009DOM(well) &
2008SurveySheet(1:1000)
Using Field Work Result To Test Model Accuracy

**Internal Accuracy=1.15m**

<table>
<thead>
<tr>
<th>WellNo.</th>
<th>Xsurvey</th>
<th>Ysurvey</th>
<th>XcaptureFromModel</th>
<th>YcaptureFromModel</th>
<th>Dx</th>
<th>Dy</th>
<th>D(horizontal)</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>826661.21</td>
<td>832303.53</td>
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<td>-1.84</td>
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</table>

System error may existed
Using mean to rectify
Using Field Work Result To Test Model Accuracy

Internal Accuracy = 1.28m

<table>
<thead>
<tr>
<th>WellNo.</th>
<th>Xsurvey</th>
<th>Ysurvey</th>
<th>XcaptureFromModel</th>
<th>YcaptureFromModel</th>
<th>Dx</th>
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<tr>
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Using Field Work Result To Test Model Accuracy

**Internal Accuracy=1.22m**

<table>
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<th>Xsurvey</th>
<th>Ysurvey</th>
<th>XcaptureFromModel</th>
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<th>Dx</th>
<th>Dy</th>
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Using Field Work Result To Test Model Accuracy

**Internal Accuracy=2.75m**

<table>
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<th>YcaptureFromModel</th>
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<td>831768.69</td>
<td>0.42</td>
<td>0.68</td>
<td>0.80</td>
</tr>
</tbody>
</table>
Model Comparison

1. Model 60 field-bund
   - 27 control points used in the exterior orientation
   - $M_{\text{horizontal}} = 1.15\text{m}$

2. Model 67 field-bund
   - 24 control points used in the exterior orientation
   - $M_{\text{horizontal}} = 1.28\text{m}$

3. Model 73 field-bund
   - 25 control points used in the exterior orientation
   - $M_{\text{horizontal}} = 1.22\text{m}$

4. Model 73 field-bund*
   - 5 control points used in the exterior orientation
   - $M_{\text{horizontal}} = 2.75\text{m}$

5. Model 73 well
   - 4 control points used in the exterior orientation
   - $M_{\text{horizontal}} = 1.08\text{m}$

6. Model 09 well
   - 5 control points used in the exterior orientation
   - $M_{\text{horizontal}} = 0.30\text{m}$
Though the formed DOM and the old survey sheet are at same accuracy level, we still suggest to adopt the DOM as priority reference.

- More reliable than old survey sheet
  (2 Cases will be given)

- have 3D property (better for measurement)
Maps should be used together with photos

Area in 1960

Area in 1963 (photo)

Area in 1967 (without update)

Area in 1973 (finally update)
Path in 1960 (curved)
Path in 1963 (straight)
Path in 1967 (curved)
Path in 1973 (straight)
Conclusion

- Precise exterior orientation reference points control the model accuracy
  - Best accuracy achieved – Wells 0.3 m
  - General accuracy using old maps - 1.2 m
Thank You!