

Precise Coordinate LIS for Improving Planning and Land Registration Processes in the Modern Real Estate Markets

Yossi Kraus⁽¹⁾, Uri Shoshani⁽²⁾, Yerach Doytsher⁽³⁾

- (¹) President, Israeli Licensed Surveyor Association
(²) Past President, Israeli Licensed Surveyor Association
(³) Technion - Israel Institute of Technology

Outline

- The current Israeli cadastre
- Analytical cadastre & Precise LIS
- Previous research
- Mathematical & cadastral transformations
- Pilot project
- Cadastre and real estate markets
- Conclusions and summary

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The Current Israeli Cadastre

- Torrens method - Registration of titles
- 80 years of Cadastral mapping (since 1926)
 - ⊃ 21,000 sq. kilometers
 - ⊃ ~15,000 cadastral blocks
 - ⊃ ~1,000,000 cadastral parcels
 - ⊃ ~4.5% of the country still not cadastral mapped & registered
- Measurements of boundaries are kept on "paper"
 - ⊃ Field books & field sheets
 - ⊃ Evidence for the statutory validity of land boundaries

Characteristics of the Israeli Cadastre

- Scale of 1:1250 to 1:2500
 - ⊃ 70% of the existing maps in Israel
- Chain surveying
 - ⊃ 65% of the existing blocks in Israel
- Blocks were manually plotted
 - ⊃ 60% of all cadastral maps in Israel
- Surveying regulations
 - ⊃ Positional accuracy: less than 10 cm.

Problems and Difficulties

- Inherent contradictions and inaccuracies in the existing cadastral material
- Delays in tracking and measuring the changes and updating the cadastral maps
- Urban and regional planning is carried out based on the non-precise graphical cadastre
- Complexity in preparing the mutation plans
- Very long processes of registration the ownerships (after land re-parcelation)

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Solution: Analytical Cadastre & Precise LIS

- **The solution: replacing the current cadastre which has a "graphic nature" with an analytical cadastre/precise LIS**
- **Analytical cadastre/precise LIS**
 - The location of each entity is unequivocally determined precisely by the state plane coordinate system
 - It will constitute a spatial information system defining the statutory land division
- **Obtaining the digital mapping data is the bottleneck in the process of establishing the analytical cadastre**

Analytical Cadastre & Precise LIS

- **Several basic sources are available:**
 - Field measurements of land boundaries
 - Digitizing (scanning) existing maps
 - Processing the existing surveying data
- **Resurveying all land boundaries is a radical solution**
 - Restoring the boundaries as-is and measuring the restored boundaries is an impractical solution
 - It constitutes a tremendous effort
 - It requires a huge number of professional surveyors, technicians, etc. (probably unavailable)

Analytical Cadastre & Precise LIS (cont. 1)

- **Digitizing (scanning) existing maps**
 - A simple process, non expensive and a fast way of obtaining digital data
 - SOI (Survey of Israel) digitized/scanned during the late 1990s the 15,000 cadastral block sheets and established a continuous LIS database
 - This cadastral database has a graphical nature, is not accurate enough, and has no legal statutory validity
 - It serves mainly managerial purposes and not cadastral applications

Analytical Cadastre & Precise LIS (cont. 2)

- **Processing the existing surveying data**
 - Field books and field sheets
 - Combining the old measurements with a limited number of new measurements
 - Relying on features that are well defined in the field
 - Using external cadastral and geometrical information
 - The mathematical solution should be based on:
 - **Least Squares adjustment**
 - **Appropriate transformations**
 - **Applying constraints (cadastral & geometrical)**

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Previous Research

- **Developing a precise and accurate analytical cadastre is an ongoing issue for the last 10-15 years**
- **Previous research has been focusing on particular issues; not on from a countrywide viewpoint**
- **One of the solutions for urban (unchanged) areas:**
 - New measurements of buildings as an anchor objects
 - New computation of original field books
 - A geometrical and cadastral adjustment process
- ➔ **Accuracy of the adjusted coordinates - better than 0.10 meter**

Previous Research (cont.)

- **One of the solutions for rural/suburban (redeveloped and/or reconstructed) areas:**
 - Is based on photogrammetric means
 - Using aerial photographs from previous periods enables to re-measure the “vanished” features
 - A “virtual journey in time” by geo-referencing old and new sets of aerial photographs enables reconstructing the original cadastral reality.
- ➔ **The accuracy of the coordinates of the cadastral parcel corners was in the range of 0.10 up to 0.30 meters**

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Transformations

- **Transformations – a tool for converting analogue cadastral maps to digital cadastral data**
 - Global transformations - a mathematical/geometrical model with various degrees of freedom
 - A rigid-body transformation - three degrees of freedom
 - Conformal – four degrees of freedom
 - Affine – six degrees of freedom
 - Polynomial based transformations - with higher degrees of freedom
 - Local transformations - a mathematical (usually a non geometrical) model
 - Rubber sheeting mechanism (many versions)
 - Constrained and non Constrained Delauny-Triangulation
 - Methods based on finite elements

Transformations (cont.)

- **Good results through global or local transformations may be achieved only if**
 - The analogue and the digital datasets are identical and homogeneous in their accuracy characteristics
 - Have linear distortions behavior throughout the data sets
- **In many cases of the cadastre these assumptions are not fully justified**
- **Applying a non-supervised global/local mathematical transformations on multi-patches cadastral datasets will probably fails (unsatisfied and non-accurate results)**

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Pilot Project

- **The Survey of Israel initiated (2006) a pilot project**
 - Composed of 60 cadastral blocks located along the Mediterranean seashore in 4 different zones
 - We were involved in the pilot project of one of these zones
 - Located in the center of Israel covering an area of ~ 5.5 km in the south-north direction and less than 1 km in the east-west direction
 - The area is covered by 15 cadastral blocks and about 200 mutation plans
 - The maps (cadastral blocks and mutation plans) were measured during a period of several decades in different measuring technologies
 - They were kept as analogue documents (field books and field sheets)
 - They were based on three different grid systems - local, old (Cassini-Soldner) and New (Israeli Transverse Mercator) systems

Measuring and Processing

- **Processing stages:**
 - A very careful field study has been carried out
 - The authentic data have been searched for, identified and measured (in the new 2005 GPS based Israeli Grid)
 - The average number of polygon points, border points and original details per cadastral block was about 60-70 points
 - All field books have been recalculated
 - For all cadastral blocks (whenever they have been found)
 - For all mutation plans (whenever they have been found)
 - The current borders of the cadastral blocks have been measured

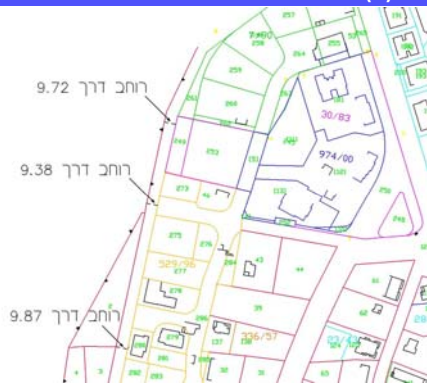
Measuring and Processing (cont.)

- **First processing stage – a mathematical approach:**
 - The cadastral borders has been transformed to new 2005 Israeli Grid
 - Entire cadastral blocks were processed based on all authentic and identified control points
 - Applying non-supervised standard mathematical transformation models
 - The numerical results were disappointing and unacceptable
 - Residuals of the control points were in the range of many decimeters (up to and above than 1 meter)

Global Mathematical Transformations (1)

control and border points - new vs. old measurements										
	7043	7115	7120	7138	7142	7143	7145	7146	7230	project
points	12	20	3	7	6	8	10	14	3	83
	DX									
min	-0.54	-0.34	-0.07	-0.63	-0.27	-0.02	-0.01	0.10	0.09	-0.63
max	0.42	0.32	0.33	0.17	0.55	0.43	0.45	0.32	0.11	0.55
average	0.09	0.12	0.09	-0.09	0.10	0.13	0.23	0.21	0.10	0.13
median	0.14	0.14	0.02	0.00	0.09	0.12	0.20	0.20	0.10	0.14
std	0.25	0.16	0.21	0.26	0.26	0.14	0.14	0.07	0.01	0.19
	DY									
min	-0.32	-0.23	0.02	-0.07	-0.12	-0.26	-0.53	-0.40	-0.21	-0.53
max	0.16	0.54	0.10	0.34	0.02	0.27	0.14	0.31	0.07	0.54
average	-0.12	-0.08	0.06	0.17	-0.06	-0.04	-0.13	-0.05	-0.09	-0.05
median	-0.14	-0.14	0.07	0.06	-0.06	-0.04	-0.05	-0.05	-0.12	-0.06
std	0.15	0.19	0.04	0.16	0.06	0.18	0.23	0.17	0.14	0.18

Global Mathematical Transformations (2)



Measuring and Processing (cont.)

- **A careful analysis of the initial results pointed out:**
 - A heterogeneous scattering of the residuals within the block
 - Patches of homogeneous behavior of these residuals
 - A significant correlation between these patches and the original mutation plans
- **A "cadastral mechanism" of transformations has been adopted**



"A second processing stage"

Measuring and Processing (cont.)

- **Meaning of a "cadastral mechanism":**
 - The cadastral information has been subdivided into its original "patches"
 - Each patch was an original single surveying project
 - Each one of these patches has been transformed separately
 - It was based on the authentic control points
 - Using the simplest (rigid-body) transformation mechanism
- ➔ **Excellent results**
 - ➔ **Deviations of few centimeters between adjacent mutation plans within the same cadastral block**
 - ➔ **Typically deviations in the range of 1-2 decimeters between adjacent cadastral blocks**

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Cadastral and Real Estate Markets

- **Establishing a precise coordinate LIS has major effects:**
 - Measuring and surveying processes
 - Saves multiple measurement of the same land area over different points in time and for different uses
 - Economizes the per measurement cost (no need to repeatedly conduct the entire tedious measurement process)
 - Planning and Land Registration processes
 - Accelerates the execution of land use conversion and alterations in planning programs
 - Decreases the time cycle needed for a re-parcelation to be implemented and new ownerships to be registered
 - Incorporates a fairness effect: the objective measurement mechanism prevents from the more powerful party to exercise its power in case of dispute

Cadastral and Real Estate Markets (cont.)

- Modern Real Estate Markets
 - Allows a reliable land valuation
 - Accelerates the execution of real estate transactions
 - Decreases the uncertainty that accompanies real estate transactions
 - Prevents the transaction costs that correspond to disputes and lawsuits between landowners, stakeholders, and other potential conflicting interests
 - Reduces the involved transaction costs and allows a more efficient decision making

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Conclusions and Summary

- **Efforts to establish an analytical cadastre in Israel is an ongoing issue for the last few years**
- **A pilot project (initiated by SOI) intending to precisely transform graphical cadastral maps into a legal analytical cadastre has been carried out**
- **Our main conclusions are:**
 - Transformation laws cannot be foreseen in advance (currently far from having automatic unsupervised processes)
 - Most of the original measurements (field books) are accurate in terms of proper front lengths and parcel areas

Conclusions and Summary (cont.)

- Inaccuracies are mainly the result of merging separate patches (separate cadastral/mutation plans) via mathematical unsupervised transformations
- In blocks that have many mutation plans, each mutation plan must be examined by its self and being transformed based on cadastral (and not mathematical) mechanism
- Until achieving a comprehensive and continuous and precise analytical cadastre, we still have to utilize past border points for carrying out cadastral projects in the present
- **An accuracy of a precise LIS at the level of ~1-2 decimeters is a realistic goal**

Thank You