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An algorithm for monitoring informal constructions – An application in coastal areas

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Coastal areas and land development

Coastal areas more developed than continental areas

- Overconcentration of human activities
- Lack of planning policy
  - Unplanned development
  - Informal settlements
- When in large scale, environmental risk

The case of Greece

- Extended coastline
- Strict regulations governing coastal areas' development
  - common use zone ~ 30-100 m width along the coast
  - specific land use types for coastal areas
- Increased demand for land in coastal areas
  - residential use
  - tourist use
- High land value
- Informal buildings in case of
  - lack of spatial planning policy
  - lack of cadastre

Informal building in Greece

- Good constructions
- One or two stories
- On legally owned land parcels
- Approximately 1 out of 3 new houses are in violation or without building permit
- Estimated 1,000,000 informal residences (out of 7M)

Informal building in Greece

Coast of Salamina island

Informal building in Greece

Coast of Keratea

Monitoring informal building

- Important to locate and monitor
- Technical and administrative issues
- Automatic and objective procedure
  - low cost technique
  - no bureaucracy or corruption

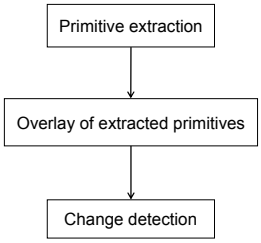
Contribution of modern photogrammetric techniques for the design of an automated and objective procedure for the detection of informal constructions

Prerequisites of technical procedure

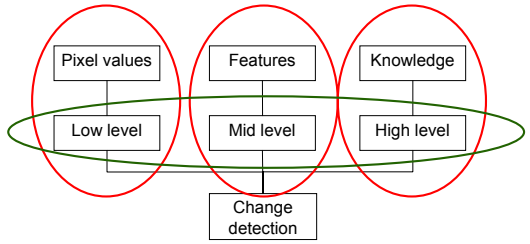
Informal building monitoring = Change detection + Legality

- Periodic control at short epochs over a large site
  - Automation
  - Low cost of data
- Monitoring of change in single building scale
  - High accuracy
  - No omissions
- Legality assessment aided by user

Change detection strategy



Change detection approaches



Commercial change detection software

- e-Cognition™, Defiens
  - object oriented classification
  - image segmentation
  - a priori knowledge
  - fuzzy logic
- Feature Analyst™, Visual Learning Systems Inc.
  - machine learning
  - training, correction, iteration

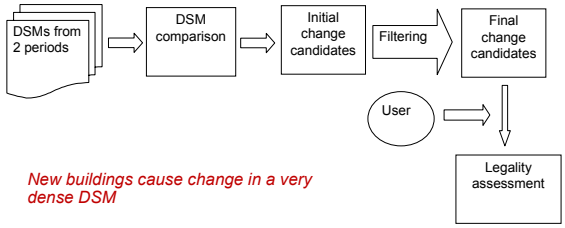
Commercial or custom made software?

	Commercial software	Custom made software
Cost	😐	😐
Flexibility	☺	☹
Robustness	😐	☺
Accuracy	😐	☺
User friendly	☺	😐

Proposed approach

- Characteristics
  - based on custom made software
  - simple algorithm
  - low development and operational cost
  - robust and accurate
- Data required
  - Aerial or satellite images
  - Dense DSMs

Overview of proposed approach

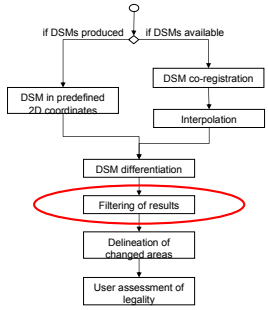


New buildings cause change in a very dense DSM

Parameters influencing the results

- Density and accuracy of the DSMs
  - building area > 50 m^2 ⟹ 10 points ⟹ 1-2 m GSD
  - building height 3-7 m ⟹ up to 1 m height accuracy
- Point to point correspondence in the two periods
  - co-registration, interpolation
  - production in the same horizontal grid coordinates
- Vegetation growth and natural anaglyph changes
  - Arid and low vegetation
  - Rare significant anaglyph changes

Flowchart of the proposed strategy



Filtering stage

1. Threshold of detected change
   $3\ m \leq \Delta Z \leq 7\ m$
2. Threshold of area size for regions detected as changed
   reject_blob if (blobSize < 10 pixels)
3. Threshold of shape and size
   SHAPE = 100% - (blob_area / circumscribed_rect)*100%
   reject_blob if (abs(SHAPE)<a AND blobSize<b)

Test application in Vravrona coast

Data used

- Aerial images
  - 1984 period
    - strip of 3 panchromatic images
    - 1:6000 scale
    - scanned at 14μm
  - 2001 period
    - stereopair of color images
    - 1:10000 scale
    - scanned at 14μm
- GCPs
  - 9 GCPs, along the edges and the center of the area of interest

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Photogrammetric procedures in LPS™

- Simultaneous aerotiangulation for both periods with bundle adjustment

	X axis	Y axis	Z axis
Average residuals of GCPs (m)	0.013	0.025	-0.017
Maximum residuals of GCPs (m)	0.210	0.162	0.126

- Automatic DSM production with 1 m GSD
- Orthophoto-mosaics with 0.2 m GSD

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Algorithmic procedure

Implementation of the algorithm in MatLAB™

Filtering parameters

Nominal height change:	3m < ΔZ < 8m
Minimum blob size:	10 pixels
Shape and size:	±20%, >200 pixels

Data input

DSMs for both periods in ASCII format
Orthohoto-mosaics in TIFF format

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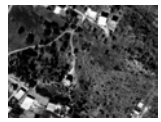
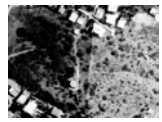
Selected test areas

1984 *2001*

- Area 1
  - Open space
  - High vegetation

- Area 2
  - Agricultural land
  - Significant changes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Selected test areas

1984 *2001*

- Area 3
  - High building density
  - Few changes


- Area 4
  - Very high building density
  - Few changes


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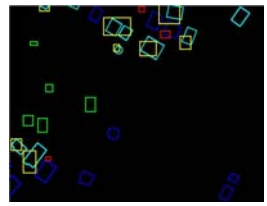
Results – Area 1

Raster format

Blue: not changed buildings' footprints
Cyan: changed buildings footprints
Green: vegetation

Vector format (overlay to manually collected footprints)



Yellow: correct changes
Red: wrong changes

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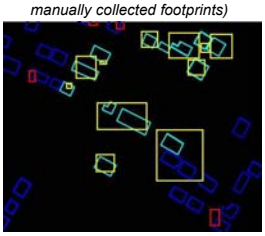
Results – Area 2

Raster format

Vector format (overlay to manually collected footprints)



Blue: not changed buildings' footprints
Cyan: changed buildings footprints

Yellow: correct changes
Red: wrong changes

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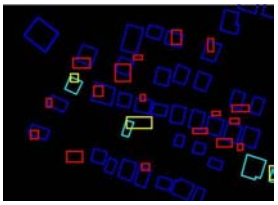
Results – Area 3

Raster format

Vector format (overlay to manually collected footprints)



Blue: not changed buildings' footprints
Cyan: changed buildings footprints

Yellow: correct changes
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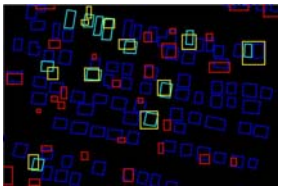
Results – Area 4

Raster format

Vector format (overlay to manually collected footprints)



Blue: not changed buildings' footprints
Cyan: changed buildings footprints

Yellow: correct changes
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Results overview

	Area 1	Area 2	Area 3	Area 4
New Buildings	9	13	3	11
Change blobs detected	15	13	19	35
Completeness	90%	100%	66%	82%
Over-evaluation	65%	0%	530%	220%

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Conclusions

- Informal development has social, fiscal, administrative and technical parameters
- The proposed technique supports the administrative task
- Quick and objective procedure
- Custom made software is used
- Commercial software cannot achieve the appropriate results
- Promising results in areas of informal building in Greece
- Further testing in other sites for fine tuning and enhancing the technique

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