FIG Working Week 2012
Knowing to manage the territory, protect the environment, evaluate the cultural heritage

TS06H – Remote Sensing II

"The use of Linear Features as Ground Control Information for the Georeferencing of Old Aerial Photos"

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Old aerial photos

- Main use: For the detection of land use changes over time.
- In Greece the aerial photos of **1945** (historical aerial photos) are used in order the forest land to be defined and protected.

- Difficulty to accurately locate and measure Ground Control Points (GCPs), necessary for the georeferencing.
  low sharpness + changes due to human activities over the years

Objective of the project

To address this problem using linear features of arbitrary geometry that tend to persist over time,
like road and stream edges (Free Form Linear Features-FFLFs),
as Ground Control Information (Ground Control Linear Features-GCLFs)

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METHODOLOGY

3D similarity transformation

3D object space (X, Y, Z) ⟷ 3D model space (Xm, Ym, Zm)

Iterative Closest Point (ICP) Algorithm

↓

Matching 3D GCLFs

GCLF: Collection of consecutive nodes of no regularity in the two spaces

Proposed procedure:

(i) computation of the closest points
(ii) computation of the georeferencing
(iii) application of the georeferencing
(iv) check of the error against a threshold

} Repetition until convergence

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APPLICATION TEST

- Study Area: at Polygyros, Chalkidiki region, Northern Greece ▷
- Datasets:

1. aerial photos taken in 1945 (scale 1:42,000),
2. stereo pair of satellite Cartosat-1 panchromatic images (GSD=2.5m), captured in August 2006, and
3. four analogue sheets of the national-wide medium scale topographic maps (scale 1:5,000), compiled in 1980.

Identification and *extraction* of 15 common linear features (regularly distributed at the study area ▷) from:

✓ dataset 1, with arbitrary X_{model}, Y_{model}, Z_{model}
✓ dataset 2 -after georeferencing (Case I)
✓ dataset 3 (Case II)

} *reference* linear features (X,Y,Z)

Matching of linear features' edges or axes ⟶ Georeferencing of old photos ▷

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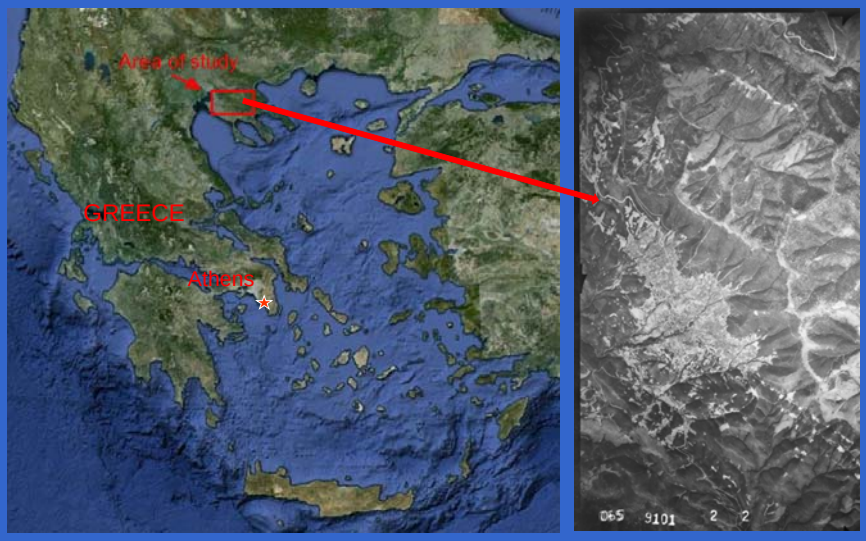
Study Area



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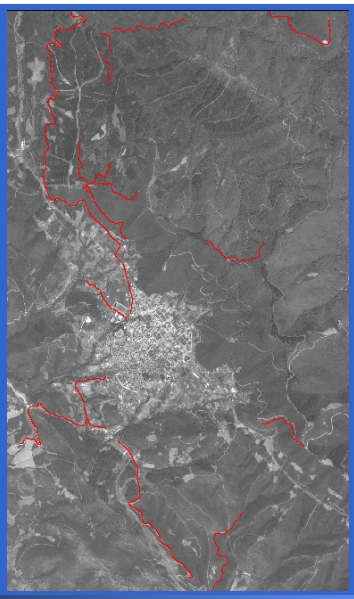
The distribution of the 15 FFLFs at the Study Area



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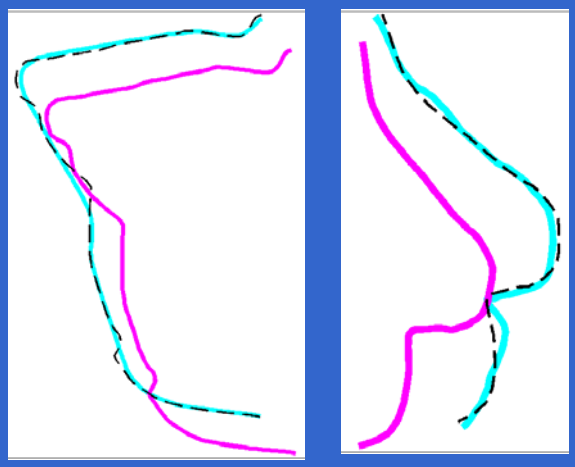
Matching Results



Road axis from topographic maps
Roughly prealigned road axis from old photos
Matched road axis from aerial photos to maps

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- Main Results:

Evaluation of the achieved georeferencing accuracy with the use of 18 independent Check Points

- ✓ Planar accuracy: 10-11 m, Vertical accuracy: 3-5 m
- ✓ The best accuracy when the axes of the linear features from the topographic maps were used as reference linear features (Case II)
- ✓ In comparison with the use of GCPs, independently from the origin of the reference linear features, better accuracies were achieved. Vertical accuracy 3-4 times better!!!

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CONCLUSIONS

- Linear features: appropriate to replace GCPs
  (+) Better georeferencing accuracies
  (+) Easier detection at the old aerial photos
  (+) Cost efficient procedure

However…
(-) Time consuming procedure $\xrightarrow{\text{solution}}$ semi-automated techniques

- Use of the corresponding points of FFLFs as GCPs

- Further investigation on other areas with a variety of characteristics
- Investigation of the impact of self-calibration procedures
- Improvement of the proposed method by calculating the georeferencing parameters by using a network of linear features

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THANK YOU FOR YOUR ATTENTION !

VI RINGRAZIO PER L' ATTENZIONE !

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