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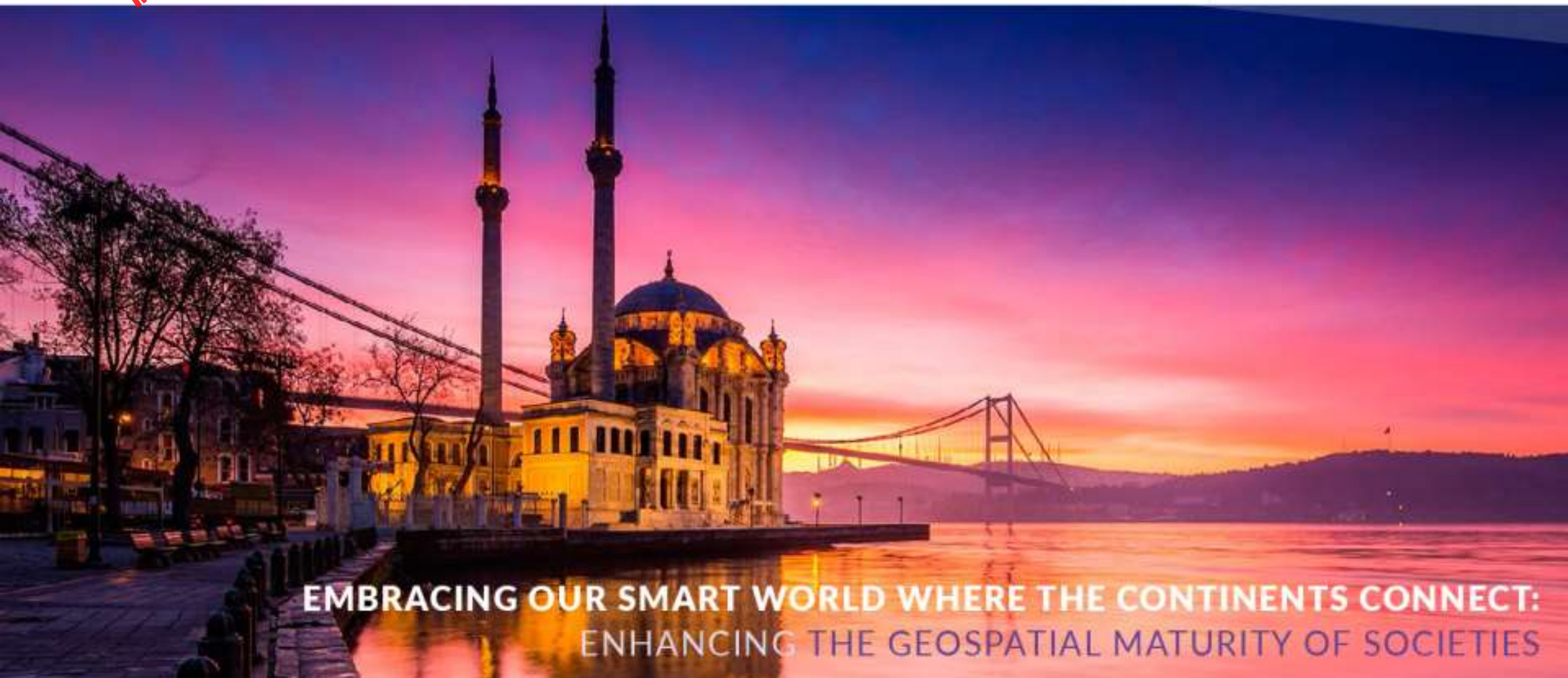

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Challenges and Opportunities in Developing Innovative Geospatial Tools for Fit-For-Purpose Land Rights Mapping

ITS4LAND
innovations for land tenure

This project has received funding from the European Union's Horizon 2020 research and innovation programme, under Grant Agreement No 687828

Horizon 2020
European Union funding
for Research & Innovation

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The Land Tool Evolution

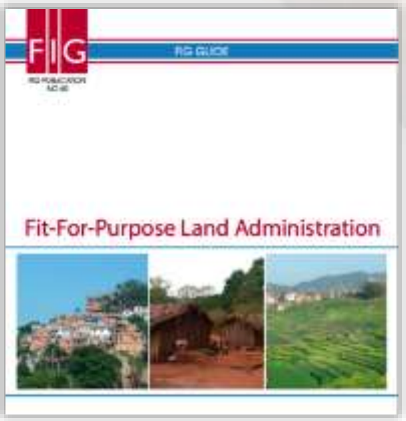
Only 30% of the world's population has access to formal land administration systems to register and protect their land rights.

Mapping cadastral boundaries using traditional, field based methods often proves to be time, cost and labour intensive.

The Land Tool Evolution

Recently there are many evidences that show that the existing ICT-based approaches for land tenure recording – do not deliver what is expected.

- **1st Generation – Conventional**
  - precise, expensive, complex procedures,
  - requiring specialists, imported, government driven (mostly)



- **2nd Generation – Pro-Poor / Fit-for-Purpose**
  - cheaper, less accurate, simpler, barefoot, para-surveyors,
  - bottom-up, manual, participation, grass roots, diversity, scalable...?
- **3rd Generation – Socio-Technical Fusion**
  - high tech, human touch, partnerships, innovation/market focused,
  - end-user driven, automation, artificial intelligence, robotics

Program: H2020-ICT-2015
Type of Action: Research and Innovation (RIA)
Topic: International partnership building in low and middle income countries
Acronym: its4land
Number: 687828
Duration: 48 months
Start Date: 2016-02-01
Consortium: 8 partners
Budget: 3.9 M EUR

ITC UNIVERSITY OF TWENTE.
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INES RUHENGERI SCIENTIA ET LUX
BAHIR DAR UNIVERSITY
TECHNICAL UNIVERSITY OF KENYA
esri Rwanda
Hansa Luftbild German Air Surveys

Its4land - Aim

To develop innovative tools to make
land rights mapping
faster, cheaper, easier, and more responsible

Its4land - Innovation

The innovation process incorporates a broad range of stakeholders and emergent geospatial technologies including:

- Smart sketch maps
- Unmanned Aerial Vehicles (UAVs)
- Automated feature extraction
- Sharing and publishing through geocloud services

The aim is to combine these innovative approaches with the specific needs, market opportunities and readiness of end-users in the domain of land tenure information recording in East Africa.

Case locations

RWANDA - developing approaches that can support updating, at scale, land rights documents and maps

KENYA - adapting tools to enable mapping of pastoralist land rights and layered disputes

ETHIOPIA - developing approaches that improve plot recordation of urban smallholder and dwellers (peri-urban and rural landscapes)

Contextualization - Get Needs

KUL – Capture the specific needs, market opportunities, and readiness of end-users in the domain of land tenure information recording.

In 2017, they engaged with 57 organizations and community groups across the three case countries (more than 100 individuals) – Ethiopia, Kenya and Rwanda

Draw and Make

WWU Munster - Implementation of a sketch based geospatial data recording to capture land tenure data from local perspective.

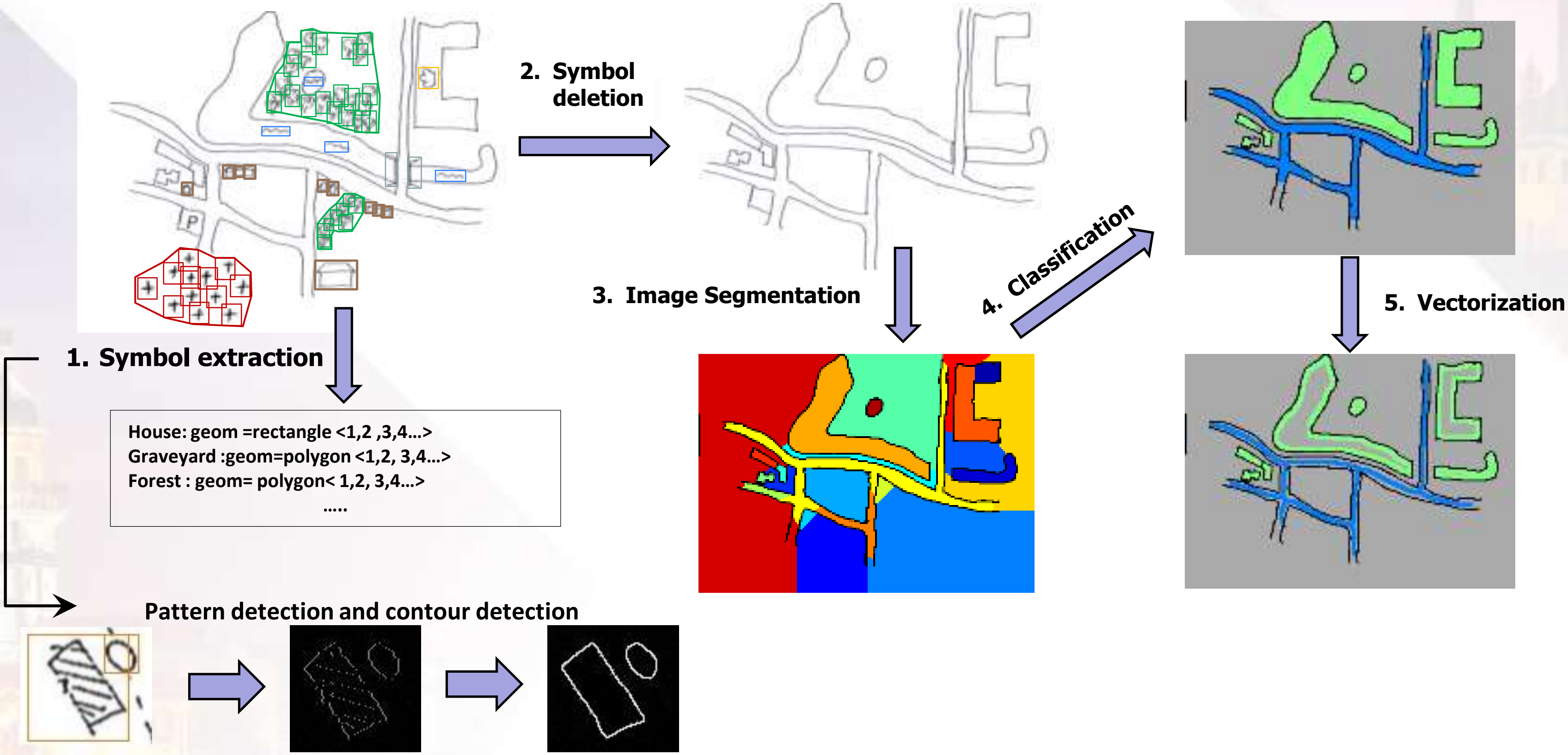
Field visits to Kajiado, Kenya and Bahir-Dar Ethiopia
(data collection, data verification/validation)

Draw and Make – main activities

Development of

1. A domain model for representing sketch maps
2. A system for automatic recognition of land tenure sketch maps;
3. Spatial models for representing sketch maps as land tenure records;
4. Embedding land tenure sketch maps within existing spatial data sets (sketch map alignment).
5. LADM extensions to integrate local domain models

Draw and Make – task overview (Object recognition)

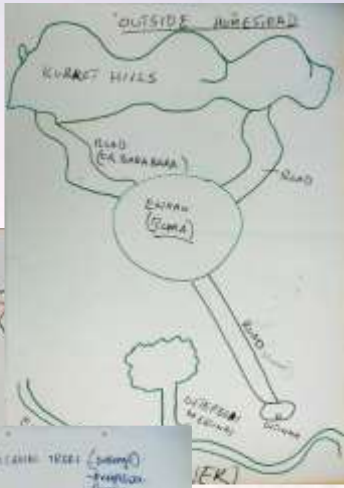
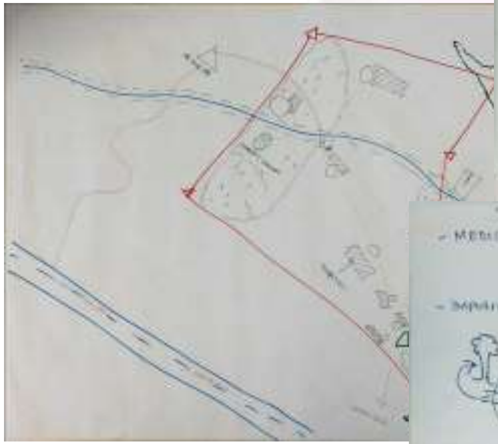


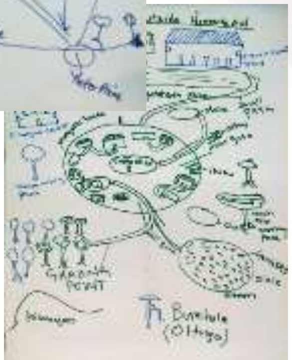
Draw and Make – data collection/verification

Data covering large geographic areas should be collected at multiple scales

1. Large scale maps around areas of interest (highly informative regions)
2. Small scale to cover larger regions
3. Maps can then be joined by providing cross references

Supplementary materials used:
Cadastral, topographic maps, aerial and satellite images

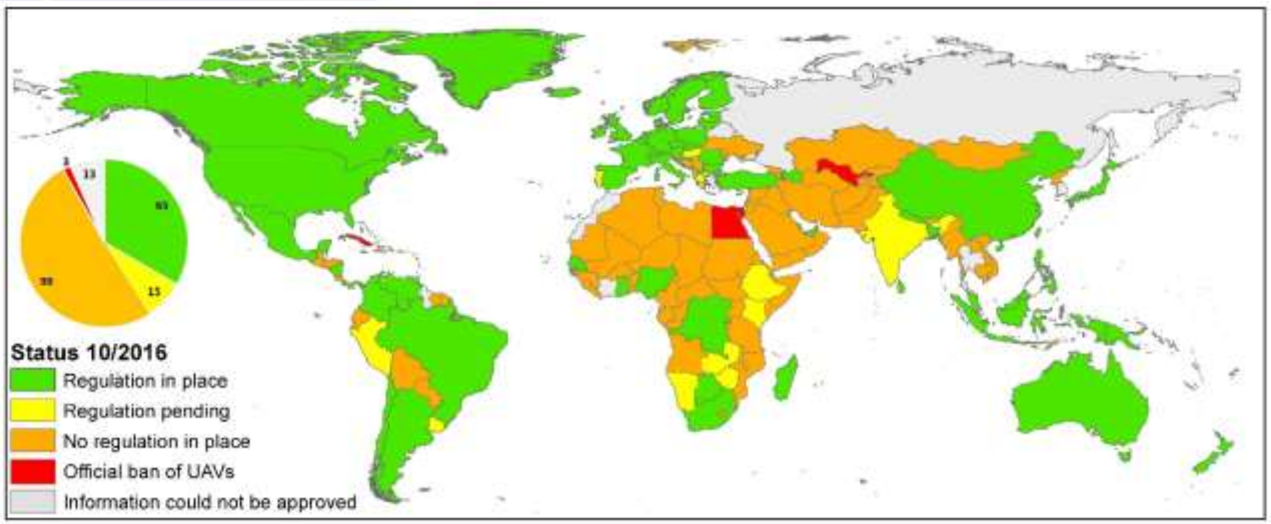






UAV workflow for land tenure data acquisition

UT (ITC) – To design, test and validate UAV workflow

Synthesis on the current state of UAV regulations



Stöcker, C.; Bennett, R.; Nex, F.; Gerke, M.; Zevenbergen, J.: Review of the current state of UAV regulations. In: Remote Sensing. 2017, 9, 459;

UAV workflow for land tenure data acquisition

- Selection of a suitable UAV
- Purchase, shipping and import UAVs
- Pilot training for 8 trainees (UT, HL, BDU, TUK, INES, ESRI)

- Fixed wing UAV, 60 min of endurance
- Payload:
  - Industrial grade RGB camera
  - IMU/GNSS Applanix APX-15

UAV workflow for land tenure data acquisition

- Selection of a suitable UAV, purchase, shipping and import UAVs
- Pilot training for 8 trainees (UT, HL, BDU, TUK, INES, ESRI)

Fixed wing UAV,
Payload:
- – Industrial grade RGB camera
- – IMU/GNSS Applanix APX-15

Reasons for selection:
- With a flight time of up to 90min the UAV can capture more than 1 km² during one flight with a GSD of less than 3cm.
- Allows for direct georeferencing (reducing the ground surveying work)

UAV - data collection

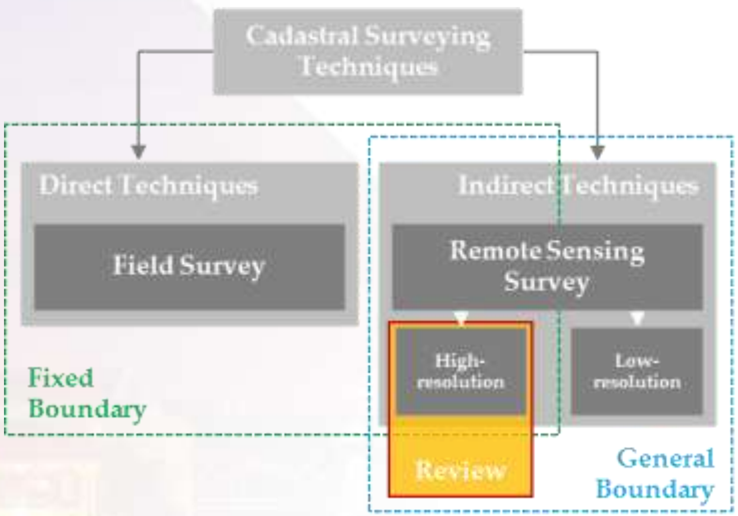
- Test flights in Germany (testing different ground trothing strategies and processing scenarios)

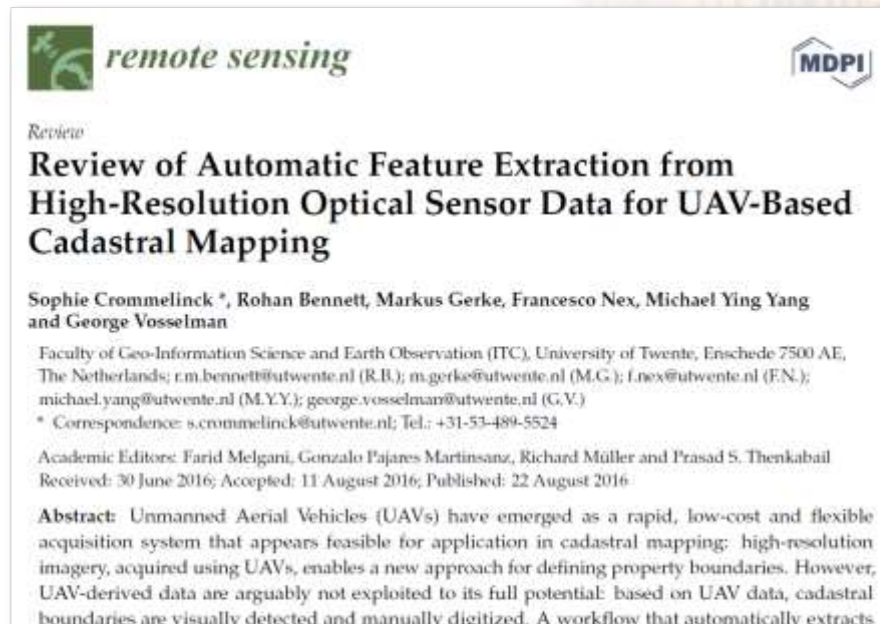
- Successful flights in:
  - Rwanda (Charis UAS)- urban and peri urban area – Musanze)
  - Kenya (rural Maasai land and in peri-urban Kisumu)
  - Zanzibar (World Bank collaboration)

Automate

UT (ITC) – To design a tool for automatic delineation of visible cadastral boundaries based on UAV images

Review background information





remote sensing

MDPI

Review

Review of Automatic Feature Extraction from High-Resolution Optical Sensor Data for UAV-Based Cadastral Mapping

Sophie Crommelinck *, Rohan Bennett, Markus Gerke, Francesco Nex, Michael Ying Yang and George Vosselman

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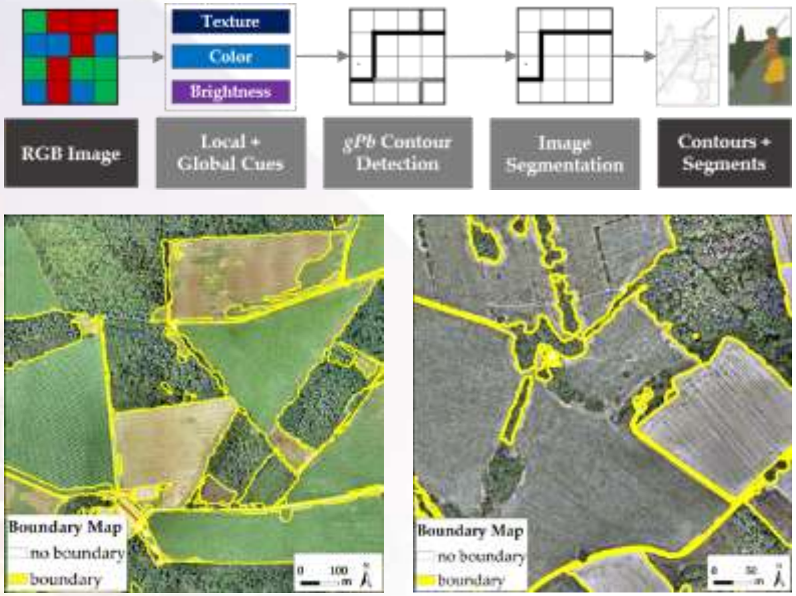
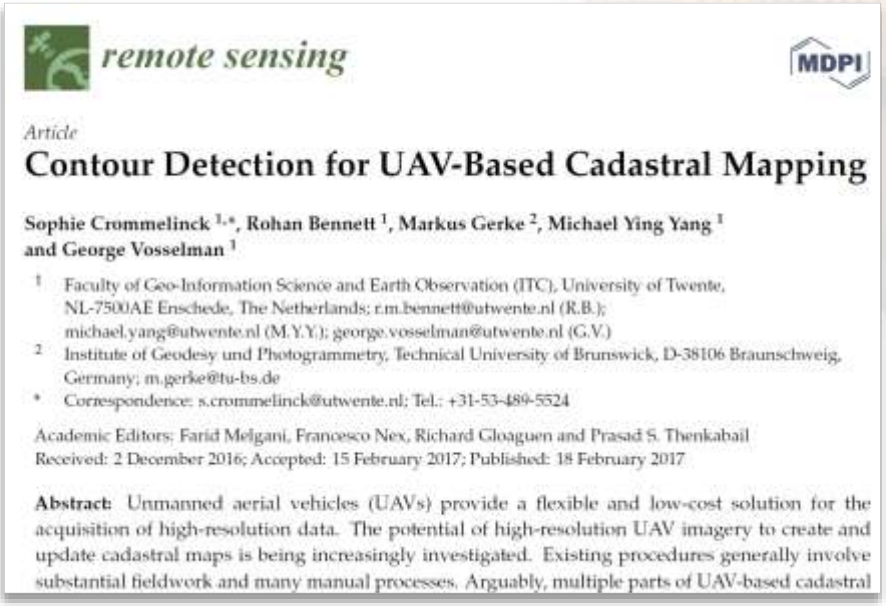
Academic Editors: Farid Melgani, Gonzalo Pajares Martinsanz, Richard Müller and Prasad S. Thenkabail
Received: 30 June 2016; Accepted: 11 August 2016; Published: 22 August 2016

Abstract: Unmanned Aerial Vehicles (UAVs) have emerged as a rapid, low-cost and flexible acquisition system that appears feasible for application in cadastral mapping: high-resolution imagery, acquired using UAVs, enables a new approach for defining property boundaries. However, UAV-derived data are arguably not exploited to its full potential: based on UAV data, cadastral boundaries are visually detected and manually digitized. A workflow that automatically extracts

Automate

Globalized Probability of Boundary (gPb) Contour Detection




remote sensing
MDPI

Article

Contour Detection for UAV-Based Cadastral Mapping

Sophie Crommelinck [1,*], Rohan Bennett [1], Markus Gerke [2], Michael Ying Yang [1] and George Vosselman [1]

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Academic Editors: Farid Melgani, Francesco Nex, Richard Gloaguen and Prasad S. Thenkabail
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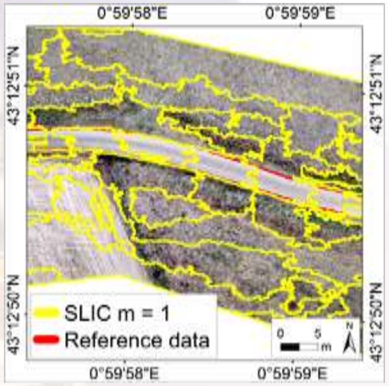
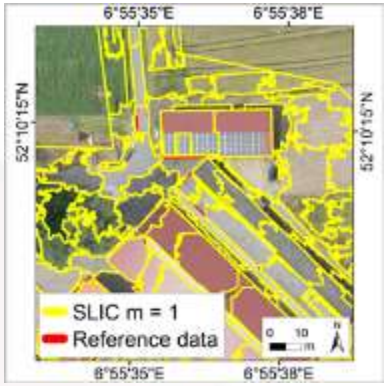
Abstract: Unmanned aerial vehicles (UAVs) provide a flexible and low-cost solution for the acquisition of high-resolution data. The potential of high-resolution UAV imagery to create and update cadastral maps is being increasingly investigated. Existing procedures generally involve substantial fieldwork and many manual processes. Arguably, multiple parts of UAV-based cadastral

Automate

Simple Linear Iterative Clustering (SLIC)





SLIC SUPERPIXELS FOR OBJECT DELINEATION FROM UAV DATA

S. Crommelinck [a,*], R. Bennett [a], M. Gerke [b], M. N. Koeva [a], M. Y. Yang [a], G. Vosselman [a]

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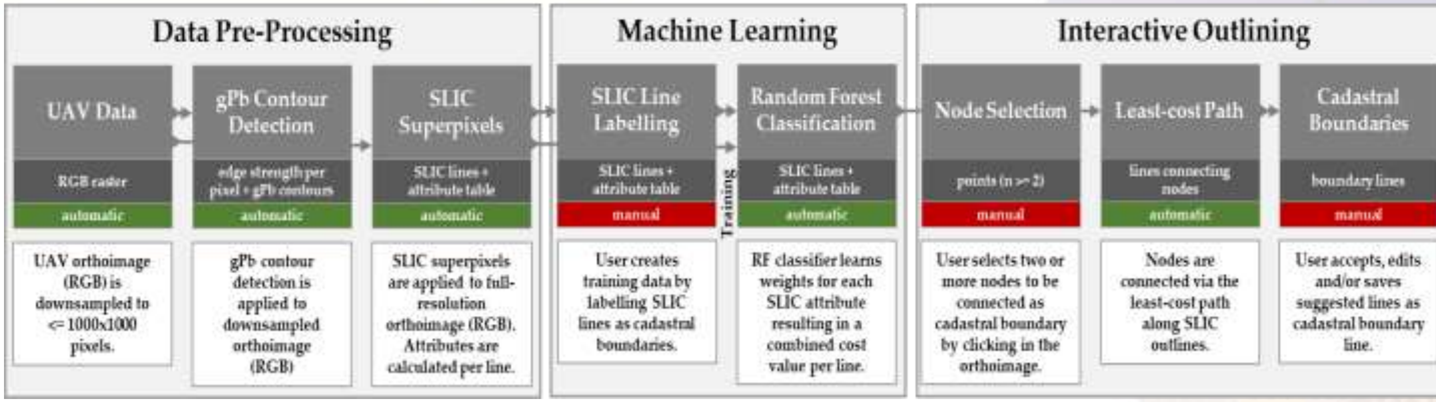
Commission #, WG #/#

KEY WORDS: UAV Photogrammetry, Image Segmentation, Object Detection, Contour Detection, Image Analysis, Land Administration, Cadastral Boundaries, Cadastral Mapping

ABSTRACT:

Unmanned aerial vehicles (UAV) are increasingly investigated with regard to their potential to create and update (cadastral) maps. UAVs provide a flexible and low-cost platform for high-resolution data, from which object outlines can be accurately delineated. This delineation could be automated with image analysis methods to improve existing mapping procedures that are cost, time and labor intensive and of little reproducibility. This study investigates a superpixel approach, namely simple linear iterative clustering (SLIC), which has, to the best of the authors' knowledge, never been applied to UAV data. The approach is investigated in terms of its applicability to high-resolution UAV orthoimages and in terms of its ability to delineate object outlines of roads and roofs. Results show that the approach is applicable to UAV orthoimages of 0.05 m GSD and extents of 100 million and 400 million pixels. Further, the approach delineates the objects with the high accuracy provided by the UAV orthoimages at completeness rates of up to 64%. The

Automate



Combination of:

- The two state-of-the-art computer vision methods: gPb and SLIC and
- Machine learning part (assigning costs to each outline according to local boundary knowledge)

Interactive user guided delineation (by calculating the least cost path by previeously extracted lines)

Results: Compared to manual delineation, the number of clicks per 100m is reduced up to 86%

Tool integration

HL- To develop a technical platform for integrating the developed tools.

The implementation follows a toolbox approach – user can select the tools of his interest.

Following the idea for geocloud the tools will be encapsulated as services with an appropriate API.

Govern and Grow and Capitalize

- To understand how these technologies can be adopted and sustained

- To develop a sustainable business model for commercialization of the integrated suite of land tenure recording tools within the end-user markets.

Website – www.its4land.com

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