geomETH

Unmanned Aerial Vehicle in Cadastral Applications

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One possibility for capturing georeferenced data is the use of UAV systems!

Background

- Growing interest in updating geodata, mainly 3D data in cadastral applications

RUHRGEBIET 3D 20.07.2011 05:13

Ruhrgebiet Vermessung in 3D

Amtliche Vermessungsdaten für die Bauplanung liefert die 3D-Vermessung des Ruhrgebiets.

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3D Vermessung mit "Inhaltsangabe"

Das Geographische Institut der Ruhr-Uni Bochum (RUB) unterstützt den Regionalverband Ruhr beim Aufbau einer digitalen und georeferenzierten 3D-Ausformung des Ruhrgebiets samt Aufbauten.

Der Vorteil gegenüber Google-Earth liegt in der Präzision der amtlichen Vermessungsdaten. Bei Planungen können so Sichtbeziehungen oder die Eignung für Solarmodule geprüft werden.

„Aus Anwendersicht müssen die 3D-Modelle aktuell, rasch generiert sowie mit inhaltlichen Informationen zu Nutzung des Gebäudes, Baujahr, verwendeten Baustoffe etc. angereichert sein", beschreibt Frank Dickmann von der RUB die Herausforderungen des Projekts. (red)

Ruhrgebiet 3D, www.solid.at

- In cadastral applications tachymeters and GNSS are mainly used

- Rapid development of UAV systems: reasonable and efficient data acquisition platform

Task

- Investigation of UAVs in cadastral surveying

- Comparison of data acquisition methods:
  - Tachymetry/GNSS (conventional method)
  - UAV system

  → Surveying of two study sites with both systems

Krattigen/BE

- Area ca. 3‘600m^2
- Agriculture zone
- Hillside
- Chalet
- Vegetation
- Street

HXE ETH Hönggerberg

- Area ca. 12‘000m^2
- Urban area
- Flat area
- Building complex
- Vegetation
- Streets

Tachymetry/GNSS method – used systems

Leica TPS System 1200	**Orientation 0.3mgon** **Distance 2mm + 2ppm**
Leica GPS System 1200	**3D-coordinate quality 2-3cm**

Krattigen

- GNSS-measurements at 4 reference points
- 3 tachymeter stations
- Measuring of building edges, major street points, vegetation (trees)

HXE

- Tachymeter measurements at 6 reference points
- 4 tachymeter stations
- Measuring of building edges, major street points, vegetation (trees)

Tachymetry/GNSS method

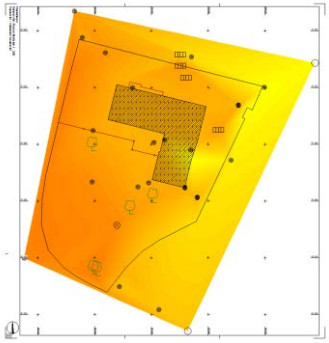
Pre-processing in LGO

- Data cleansing
- GNSS with data corrections of SWIPOS
- Code definition

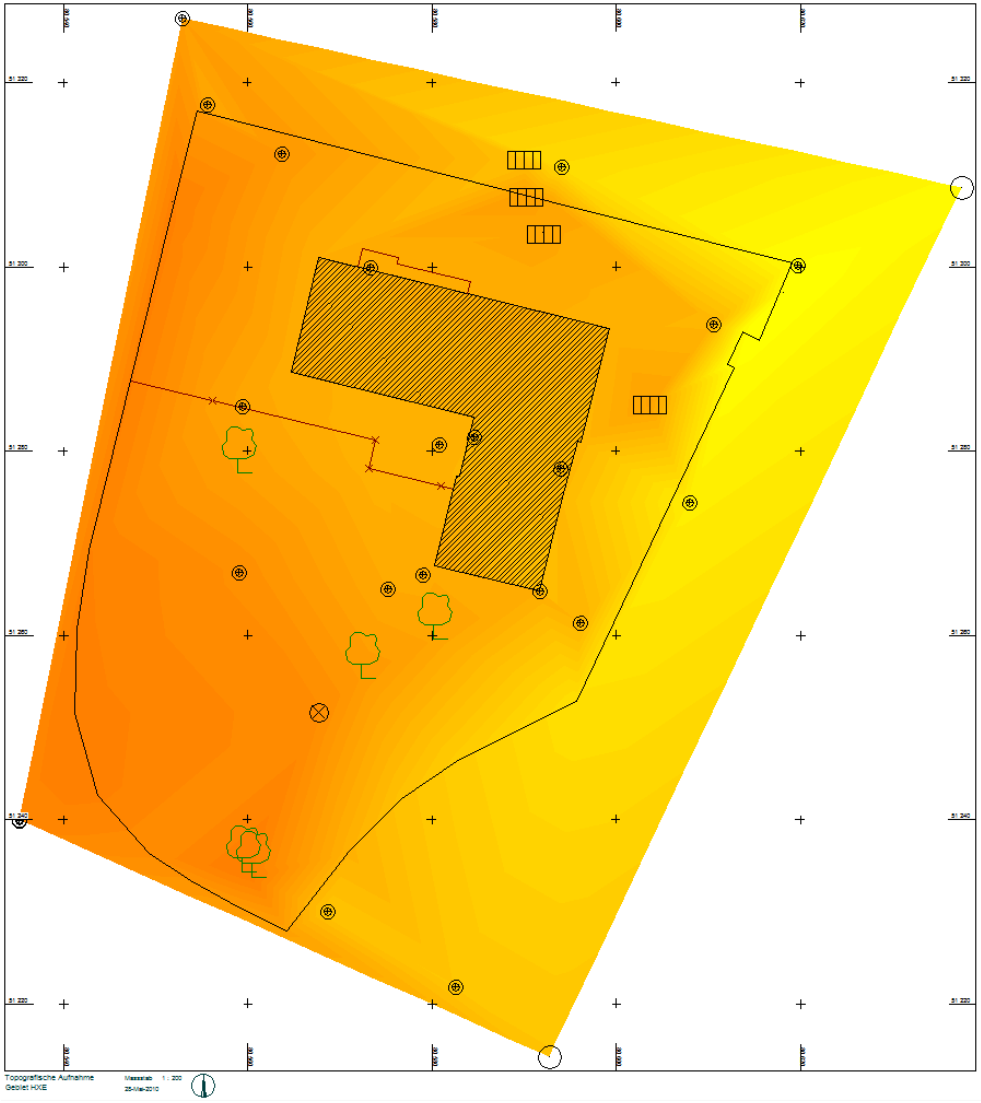
Geodetic network adjustment in LTOP

Map composition in CAPLAN

- Code and symbol definition
- Calculation of the elevation model
- Map composition



Used Methods



Resulting map in CAPLAN of HXE

UAV method – used systems

Oktokopter

- Falcon 8 AscTec
- Remote control: 5.6'' preview monitor
- GNSS, height sensor, IMU, compass

Flight time	Takeoff weight	Payload capacity	Battery
max. 20min	max. 1.8kg	500g	LiPo 8000mAh

Camera

- Panasonic Lumix DMC-LX3
- Multi format sensor (4:3, 3:2 und 16:9)

Zoom range	Weight	Sensor pixel size	Sensor size	Shutter lag incl. autofocus
24-60mm	265g inkl. Akku	~2.0µm	1/1.63“ ~8.44 x 6.33 mm	0.63 - 0.71s

UAV method – data acquisition

Krattigen

- Assisted flight mode
- 2 flight strips: min. 4 images per strip
- Façade: Stereo images
- 6 targets

Measurement positions, Krattigen, googleEarth

HXE

- Autonomous flight mode
- 4 flight strips: 8 images per strip
- Façade: Stereo images
- 6 targets

Measurement positions, HXE, googleEarth

UAV method – data evaluation

Image orientation in LPS

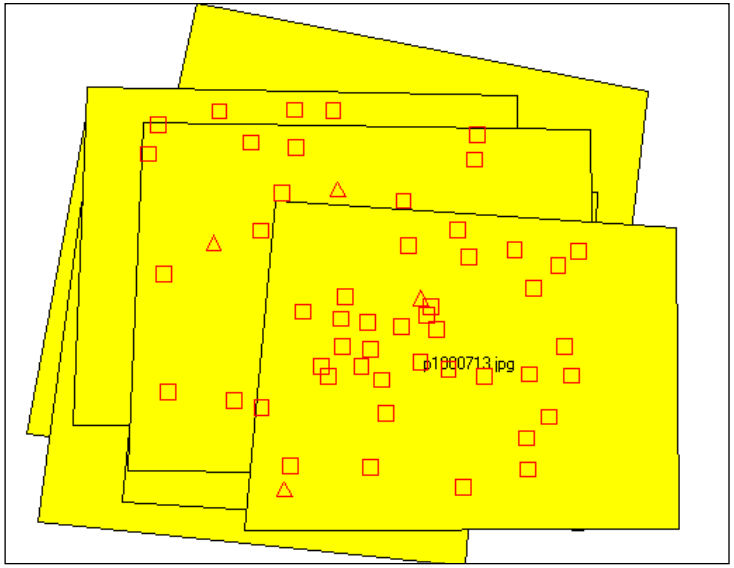


Image orientation of Krattigen

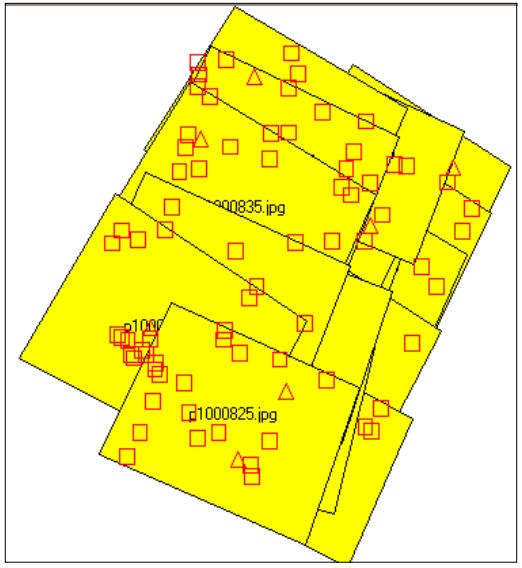


Image orientation of HXE

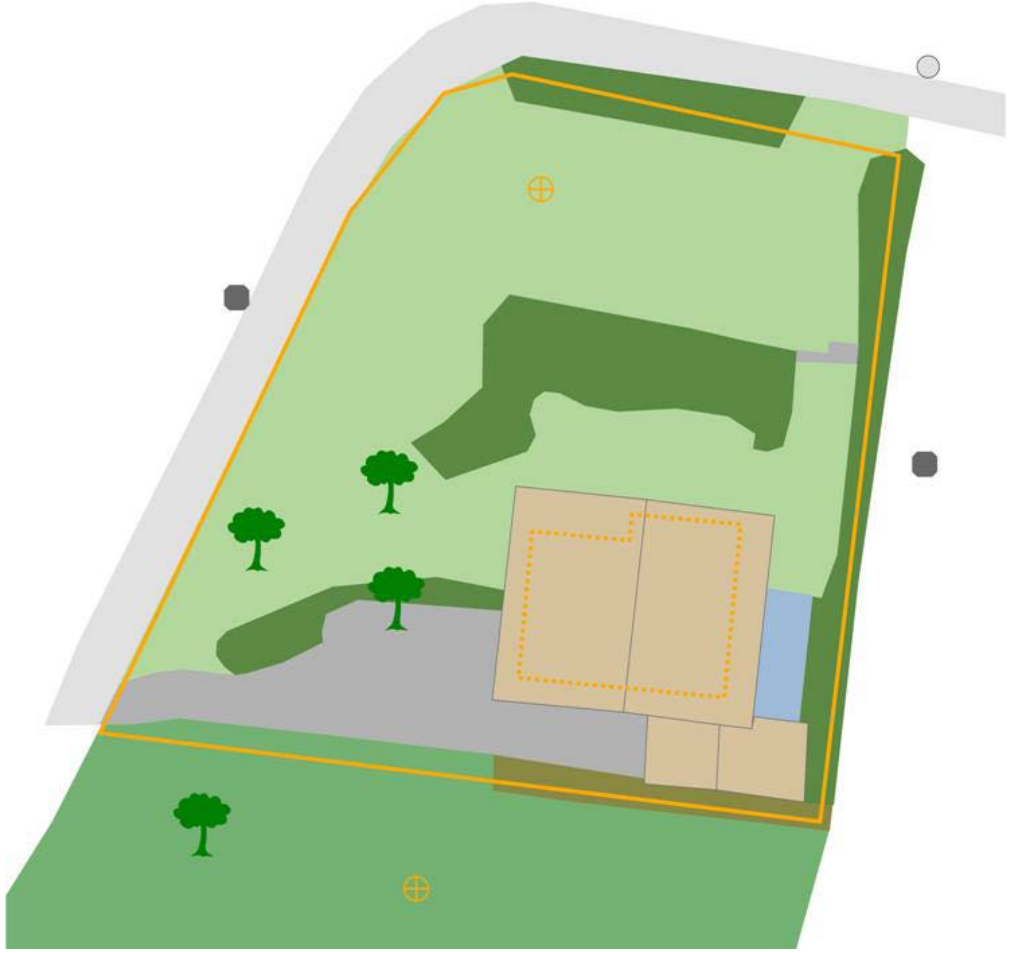
Flight	Height	σ_0	RMSE of GCP			RMSE of image observation	
		[Pixel]	X [m]	Y [m]	Z [m]	x [Pixel]	y [Pixel]
Krattigen	40 m	0.85	0.01	0.01	0.01	0.51	0.76
HXE	60 m	0.69	0.01	0.02	0.01	0.24	0.25

UAV method – data evaluation

Stereo measurements in LPS

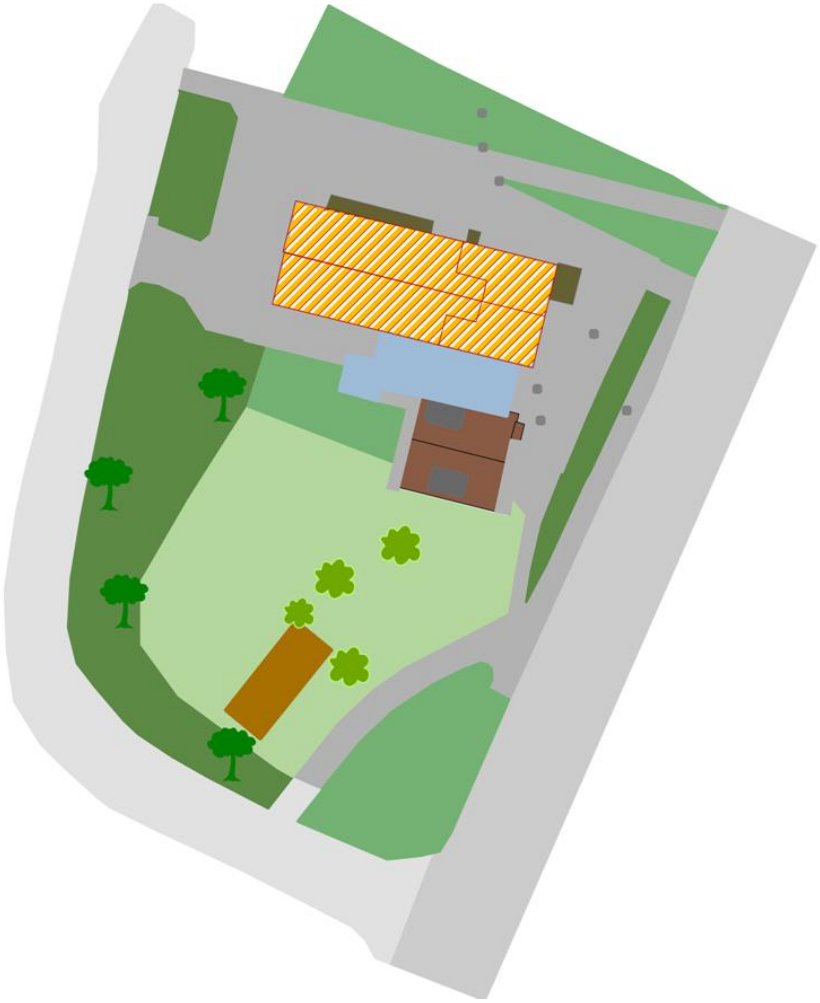
Geometry extraction in LPS (Krattigen)

Extraction of geometries, visualization in ArcGIS



Measured geometries, Krattigen

Extraction of geometries, visualization in ArcGIS



Measured geometries, HXE

Comparison of the two methods

Time needed for data acquisition and map construction

- TPS: 1 week
- UAV: 1 week incl. additional products

Additional benefit using the UAV method

- Extraction of object geometries
- Much more detailed map
- Elevation model
- Orthophoto

Cadastral restrictions in Switzerland

Art.3 TVAV

- *TS1: Central business districts*
- *TS2: Built-up areas and construction zones*
- *TS3: Intensively used agricultural and forested areas*
- *TS4: Extensively used agricultural and forested areas*
- *TS5: Alpine and non-productive areas*

	TS2 (HXE)	TS3 (Krattigen)
Lateral accuracy		
Land cover and single objects	10cm	20cm
Land ownership	3.5cm	7cm
Not exactly defined point	20cm	35cm
Height accuracy		
Height (DTM 2m Grid)	80cm	80cm
Not exactly defined terrains	200cm	200cm

Standard deviation for the zones TS2 and TS3 of the Swiss TVAV

Achieved accuracy

- TPS
  - Leica TPS System 1200
  - GNSS static + SWIPOS: 3D-coordinate quality 2-3cm
  - Geodetic network adjustment: Confidence ellipse up to 5mm

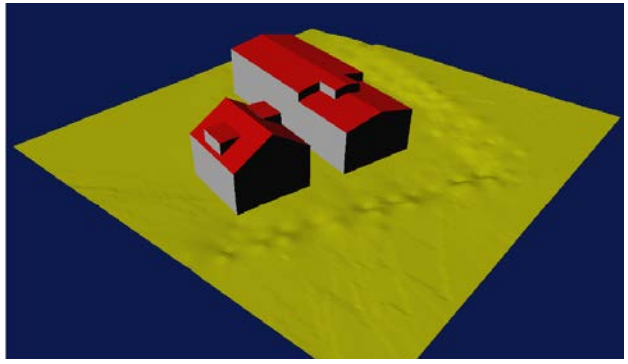
- UAV
  - Aerial images: up to 40m a. g. -> object size of 1.5cm can be detected
  - LPS coordinate average accuracy: ‘Land ownership’:
    Krattigen: lateral 2.0cm, vertical 5.0cm
    HXE: lateral 1.8cm, vertical 3.5cm

These values are below the required accuracy of lateral 3.5cm (TS2) and 7cm (TS3)!

→ **UAV’s can be used for cadastral applications!**

Additional benefit of using UAV data

- 3D models of objects such as buildings



Non-textured 3D-Model derived from UAV images of the HXE-building at Campus Science City ETH Zurich

- Applying a complete texture to the buildings

Texture components and the 3D-Model derived from UAV images of the HXE-building at Campus Science City Campus ETH Hoenggerberg, displayed in VRMLVIEW

Additional benefit of using UAV data

- The final textured model can be exported as VRML for general 3D viewers or as a KMZ file for display in Google Earth

3D-Model derived from UAV images of the HXE-building at Campus Science City ETH Hoenggerberg, imported to Google Earth

Conclusion

Both methods, tachymetry/GNSS and UAV, were confirmed to be comparable in terms of accuracy, completeness and expenditure of time.

- Limiting factors for image orientation accuracy:
  - camera calibration
  - image quality
  - definition of the ground control points in the image space

Conclusion

Advantage of using UAVs

- Ability to quickly observe the surface of areas at low flying altitude
- Fast measurement of object geometries and additional information
- Possibility to generate elevation models and 3D objects
- If the area is already documented in official cadastral surveying, further information can efficiently be gained even in a post-processing step.

Outlook

- To **decrease the complexity** of data processing the development of an **efficient workflow** for data analysis of the aerial images is needed.
- Great additional benefit to users of cadastral data, such as **real estate agencies** and **insurance companies**.
- Valuable **alternative** in areas where access can be difficult, e.g. after **natural calamities** or in **3rd world countries**.
- With further developments of specific system technology, the usability of UAV systems will increase in cadastral surveying!

Outlook

In the future, UAVs will be used where a need of **high accuracy** is required and **fast data capturing** is demanded**.**

The use of UAVs is an opportunity for cadastral surveying.

Documentation of land ownership, cadastre.ch

Thank you for your attention