APLADYN STEREO II project (SR/00/132)

Urbanisation as a threat for heritage and archaeology, the case of Cairo

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What’s the project context?

Anthropogenic and physical landscape dynamics in large fluvial systems

Aim is to explore and evaluate the possibilities of a variety of existing and recently developed RS sources and RS analysis methodologies to map the long-lasting interaction between the anthropogenic landscape and the physical environment in large fluvial systems, and the impact of these interactions on the natural and cultural heritage.
Who are the different partners?

Partner 1
K.U.Leuven - Physical and Regional Geography Research Group
Gert Verstraeten (project coordinator)
Véronique De Laet (scient. coordinator & PI)
Anton Van Rompaey
Ihab Mohamed

Partner 2
K.U.Leuven - Faculty of Arts
Dayr al-Barshā archaeological project
Harco Willems
Gertrud van Loon

Partner 3
UGent - Department of Geography
Rudi Goossens
Marijn Hendrickx

Partner 4
T.U. Delft - Department of Earth Observation & Space Systems
Ramon Hanssen
Manuel Delgado Blasco
What are the different WPs?

- **WP1: Digital elevation models**
- **WP2: Reconstruction palaeo-channels**
- **WP3: Dune-floodplain interaction**
- **WP4: Archaeological feature detection**
- **WP5: Urban development**
- **WP6: Integration & modelling**

Categories:
- **Static landscape**
- **Natural dynamics**
- **Anthropogenic dynamics**
- **Impact**
The case of the Ghiza plateau
Is the Giza pyramid plateau under pressure?
How can we analyse this urban expansion?

Accurate and detailed geographic data delivered from recent high resolution satellite images

RS has already proven to be very useful for analysing and visualising urban sprawl and land use however mainly in 2D and on large scale high resolution aerial images

Complement this data with accurate height information from DSMs for

A. 2.5D change detection

B. Viewshed analyses
Which data has been used?

2.5D change detection

2005 Ikonos panchromatic stereo images (GSD 1m – Acq. date = 9th January)

2009 & 2011 GeoEye panchromatic stereo (GSD 0.5m – Acq. date : 1 pair 2nd July ‘09 – 2 pairs 24th June ’11)

22 GCP’s measured in January 2011 with dGPS (C-Nav) with subpixel accuracy

Photogrammetric processing software: Leica Photogrammetric Software (LPS) and enhanced digital terrain extraction (eATE) module of Erdas Imagine®
Which data has been used?

Viewshed analysis

1970 **Corona panchromatic stereo images** (theoretical GSD 1.8m – Acq. date = 23rd Nov)

2005 Ikonos panchromatic stereo images (GSD 1m – Acq. date = 9th January)

2009 & 2011 GeoEye panchromatic stereo (GSD 0.5m – Acq. date: 1 pair 2nd July ‘09 – 2 pairs 24th June ’11)

22 GCP’s measured in January 2011 with dGPS (C-Nav) with subpixel accuracy
=> accompanied with extra gcp’s generated out of triangulated GeoEye’11 images

Photogrammetric processing software: Leica Photogrammetric Software (LPS) and enhanced digital terrain extraction (eATE) module of Erdas Imagine®
Which data has been used?
Data processing – accuracies DSMs

<table>
<thead>
<tr>
<th>YEAR</th>
<th>RMSE</th>
<th>Mean Error</th>
<th>LE90</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>0.522</td>
<td>0.020</td>
<td>0.858</td>
</tr>
<tr>
<td>2009</td>
<td>0.380</td>
<td>0.004</td>
<td>0.625</td>
</tr>
<tr>
<td>2011</td>
<td>0.366</td>
<td>-0.035</td>
<td>0.601</td>
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</tbody>
</table>
Data processing - example

DSM based on 2011 stereo images
Data processing – example oblique view
Study areas change detection

Location of the different study areas

<table>
<thead>
<tr>
<th>Area</th>
<th>Maximum</th>
<th>Mean</th>
<th>Standard dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mansourey</td>
<td>40.56</td>
<td>19.85</td>
<td>4.33</td>
</tr>
<tr>
<td>Pyr. Garden</td>
<td>128.68</td>
<td>97.08</td>
<td>9.04</td>
</tr>
<tr>
<td>Giza Centre</td>
<td>71.94</td>
<td>33.74</td>
<td>11.45</td>
</tr>
<tr>
<td>Ringroad</td>
<td>66.87</td>
<td>27.41</td>
<td>8.83</td>
</tr>
<tr>
<td>Hotelarea</td>
<td>111.63</td>
<td>64.93</td>
<td>21.10</td>
</tr>
</tbody>
</table>

Legend

- Mansourey
- Pyramid Garden
- Giza Centre
- Ring road
- Hotelarea

Background: Orthophoto based on GeoEye panchromatic 2009 images
Change detection – Pyramid Garden

Urban Expansion - Background: image of 2009
Data processing – Pyramid Garden

DSM urban expansion (2009)

Legend
Height
High : 133m
Low : 1m

DSM urban expansion (2011)

Legend
Height
High : 140m
Low : 1m
Data processing – 2.5D change detection

1. Median filter kernel 5 * 5 to reduce noise
2. Assumptions
   One floor = 3m high
   100m² building floor for this area (Sims, 2010)

Method adapted and modified from Stal et al. (2013)
Data processing – 2.5D change detection methodology

- Reduce city noise (median)
- Occlusion filter (slope)
- Difference
- Morphological operations (erosion and dilation)
- Map showing added volumes
Data processing – 2.5D change detection methodology

- Reduce city noise (median)
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- Map showing added volumes
Data processing – 2.5D change detection

Difference DSM 2011 minus 2009
Data processing – 2.5D change detection

Filtered DSM - Threshold 3m

Legend
- Rejected
- Accepted
Where are the new buildings and floors?
How did the view towards the pyramids evolved?

Why these points?

Distribution in the overlapping area in relation to the Pyramid Plateau

Height value +/- same over 4 decades.
How did the view towards the pyramids evolved?

- Smoothing surface
- Resample to resolution Corona (1.8m)
- Calculation viewshed (observer 1.7m)
- Combining maps
How did the view towards the pyramids evolved?
How did the view towards the pyramids evolve?

*Viewshed 1970*
- Aantal pixels zichtbaar in 1970: 1011334
  - waarvan woestijn/natuur: 863414
  - waarvan bebouwing: 147920

*Piramides zichtbaar vanaf viewpoint*

*Legende*
- Viewpoint
- Zichtbare woestijn/natuur
- Zichtbare bebouwing

*Achtergrond:* orthofoto CORONA KH-4B met Wallisfilter (1970)

*Viewshed 2005*
- Aantal pixels zichtbaar in 2005: 310856
  - waarvan woestijn/natuur: 226195
  - waarvan bebouwing: 84661
- Aantal pixels ook zichtbaar in 1970: 119820

*Piramides zichtbaar vanaf viewpoint*

*Legende*
- Viewpoint
- Zichtbare woestijn/natuur
- Zichtbare bebouwing

*Achtergrond:* orthofoto Ikonos-2 (2005)
How did the view towards the pyramids evolved?

**Viewsed 2009**
- Aantal pixels zichtbaar in 2009: 275830
  - waarvan woestijn/natuur: 199863
  - waarvan bebouwing: 75967
- Aantal pixels ook zichtbaar in 1970 & 2005: 75603

*Piramides zichtbaar vanaf viewpoint*

**Legende**
- Viewpoint
- Zichtbare woestijn/natuur
- Zichtbare bebouwing

Achtergrond: orthofoto GeoEye-1 (2009)

**Viewsed 2011**
- Aantal pixels zichtbaar in 2011: 281104
  - waarvan woestijn/natuur: 183864
  - waarvan bebouwing: 97240

*Piramides zichtbaar vanaf viewpoint*

**Legende**
- Viewpoint
- Zichtbare woestijn/natuur
- Zichtbare bebouwing

Achtergrond: orthofoto's GeoEye-1 (2011)
How did the view towards the pyramids evolved?

**Viewshed 1970**

Legende
- Viewpoint
- Zichtbare woestijn/natuur
- Zichtbare bebouwing

Achtergrond: orthofoto CORONA KH-4B met Wallisfilter (1970)

**Viewshed 2011**

Legende
- Viewpoint
- Zichtbare woestijn/natuur
- Zichtbare bebouwing

Achtergrond: orthofoto's GeoEye-1 (2011)
Conclusions

We managed to create accurate and comparable DSMs from different time periods.

2.5D change detection method can be used to estimate/analyse the urban sprawl in areas without (population) statistics.

However:
An individual vector layer is not possible
Reference data is not available for validation
> Digitalisation roof buildings

Viewshed analyses provide view into the past how the landscape around the world heritage site changed throughout the last 40 years and can/should thus be used as a management tool.
Conclusions
Conclusions
And...what it is
Thanks for your attention!

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