OBLIQUE AERIAL IMAGES: POTENTIALITIES, APPLICATIONS AND BEST PRACTICES

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The history of oblique imagery

- First recorded aerial photo in the US (1860) by J.W. Black and S. King in Boston (USA) was an oblique shot from a balloon.

- In 1906 G. R. Lawrence used between nine and seventeen large kites to lift a huge camera and take some oblique aerial images of San Francisco (USA) after the strong earthquake in the area.
Oblique cameras on airplanes gained importance for military reconnaissance during World War I and World War 2.

However, these systems were too expensive in the “analogue times”.

Oblique systems were re-introduced on the market by Pictometry more than 10 years ago.
Current oblique camera systems – Swiping camera

- Different solutions are nowadays available on the market, adopting:
  - Different number of cameras
  - Different acquisition geometries

- Single swiping camera

FAN ACQUISITION

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Current oblique camera systems – Multi-camera

2 cameras

IGI Dual

3 cameras

DLR-3K

4 cameras

IGI Digicam 4
Rolleimetric AIC x4

n-cameras

MIDAS Optoblique
Current oblique camera systems – Multi-camera

5 cameras

- Vexcel Osprey
- Leica RCD 30
- IGI Penta DigiCAM

- One nadir + 4 oblique cameras
- Modular (i.e. varying angles) vs fixed
- Small, medium or large format sensors
- RGB + NIR (in the nadir)
- Wide vs narrow angle lens

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Who is interested in the oblique systems?

- Questionnaire submitted by EuroSDR on the current status of oblique airborne imagery
- Run throughout 2014 and 2016
- 300+ participants

Advantages of oblique imagery?

- Easier identification of objects
- Increase degree of automation
- Increase reliability
- Do what is not possible today
First applications / use of oblique images

- Monoplotting / Building height measurements
- Interactive city modeling (Imagemodeler + Blomoblique)

Source: BlomUrbex

Source: Xiao, 2013
Nadir vs Oblique images and Photogrammetry

**VERTICAL:**
- Good observation of roofs, constant scale, traditional approach

**OBLIQUE – Pros / Benefits:**
- Visibility of roofs and vertical structures (feat. extraction, texturing)
- Multiple views, including nadir
- Better interpretation (building footprints, number of floors, etc.)
- Higher redundancy & reliability
- 3D vs 2.5D point clouds → more detailed 3D city models
- Improvement of the true-orthophoto automated generation

**OBLIQUE – CONS:**
- More occlusions (mitigated by multiple views and overlaps)
- Varying scale / GSD
- Big illumination changes
- Need for dedicated processing
The photogrammetric use of oblique images is challenging → researchers / companies interest

Many papers and initiatives dealing with oblique imagery are already available

Foster research concerning:
1) Fully automatic and reliable orientation of multi platform imagery
2) Dense image matching within/across platforms

- State-of-the-art is 5 images for every “acquisition position”
- Large image block size (# images)

Source: Ordnance and Survey UK
- Choose the right overlaps if a complete 3D model of the urban area is needed.

- The street’s width and the building’s height play a major role in planning a successful urban survey campaign.

- The taller the architectures, the lower the camera incidence angle must be.

- A compromise should be found between the camera tilt setting, focal length, sensor size, overlap and geometry of the area.

Data Processing – Image orientation

- Problems for traditional photogrammetric tools / approaches:
  - Convergent images
  - Varying image scale / resolution (GCPs measured with diff. accuracy)
  - Large perspective distortions (interest operators are less efficient)
  - Long processing time
Data processing – image orientation

- Different perspectives and illuminations in different image views
The final results will be many (separated) blocks, without a good strategy of concatenation of the images.

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The traditional approaches lose the connection between different sub-blocks acquired from different looking directions.

Data processing – image orientation

- Rely on GNSS/INS data
- Create a connectivity map/graph
- Use constraints like: overlap, looking direction, min num. of extracted tie points
- Exploit large observations’ redundancy

[Rupnik, E., Nex, F., Remondino, F., 2013: Automatic orientation of large blocks of oblique images. ISPRS Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, ISPRS Hannover 2013]
Data processing – Point cloud generation

- Use connectivity map/graph
- Use only images with same look direction and large overlaps in the matching process

Data processing – Point cloud generation

- Use connectivity map/graph
- Prefer images with same look direction
- Point cloud filtering
- Merge multiple point clouds (from every looking direction)

Data processing – Point cloud generation

Dense Image Matching point cloud (MicMac)
Data processing – point cloud generation

- Dortmund dataset (IGI PentaCam) – ISPRS/EuroSDR benchmark
- GSD 10cm
- > 1000 images

Data processing – True-ortho generation

Courtesy: nFrame
Applications - 3D mesh / polygonal models

Source: Toschi and Remondino, 2015
Applications - 3D building models

Point cloud → Roof segmentation and classification → Building models

Source: Toschi and Remondino, 2015
Applications – Urban Monitoring

L’Aquila earthquake

- Automated delineation of damages

Applications – Cadastral monitoring

Early NMCA experiences

Ordnance & Survey UK
- Classification
- 3D building model without prior knowledge

Ordnance & Survey Ireland
- Map updating and systematic comparison existing methodologies
Early NMCA experiences

Institut Cartogràfic i Geològic de Catalunya

- Texturing 3D models and visual inspection

General remarks
- Use of available commercial solutions (i.e. Tridicon)
- No need building footprint for 3D city modelling 😊
- More accurate modelling 😊
- Texture and additional information of façades 😊
- Huge amount of data to be managed 😞
Many systems and new ones might come out soon (sensor size?)

Oblique requires a new approach in the photogrammetric pipeline

Oblique airborne images could become a standard, complementary to traditional large format nadir images (especially in urban areas)

Oblique are complementary to traditional nadir and UAV images

Many possible applications: map update, 3D city modeling, inspection and interpretation, 3D cadaster, real estate, etc.

NMCAs are thinking to adjust their production pipeline to cope with oblique

Additional costs of oblique flights (especially additional flight lines) might be compensated by additional outcomes and benefits:

- Easier object identification / interpretation
- Generation of point clouds on vertical elements
- More reliable generation of true-orthophotos
- Extension from 2D to 3D GIS data
Final remarks and outlook

- Room for improvement in the use of oblique imagery:
  - Management of scale and radiometric changes;
  - Reliable and fast identification of homologues points, also across viewing directions;
  - Processing time and reliable big-data processing
  - Fusion of point clouds coming from different viewing directions (and with different accuracy)
  - Feature extraction and automation in interpretation in complex scenes
  - Integration of Oblique images with other data (UAV, MMS)
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Acknowledgements:
Markus Gerke (ITC, The Netherlands), Fabio Remondino (FBK, Italy), Ordnance & Survey UK, Ordnance & Survey Ireland and Institut Cartogràfic i Geològic de Catalunya