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
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
Photogrammetric use of oblique images

- 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)
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.

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
Data processing – image orientation

- The final results will be many (separated) blocks, without a good strategy of concatenation of the images.

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

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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)
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

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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)
OBlique Aerial Images: Potentialities, Applications and Best Practices

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