Pix4D

Pix4D: Accurate, hands-free mapping from low cost UAV imagery

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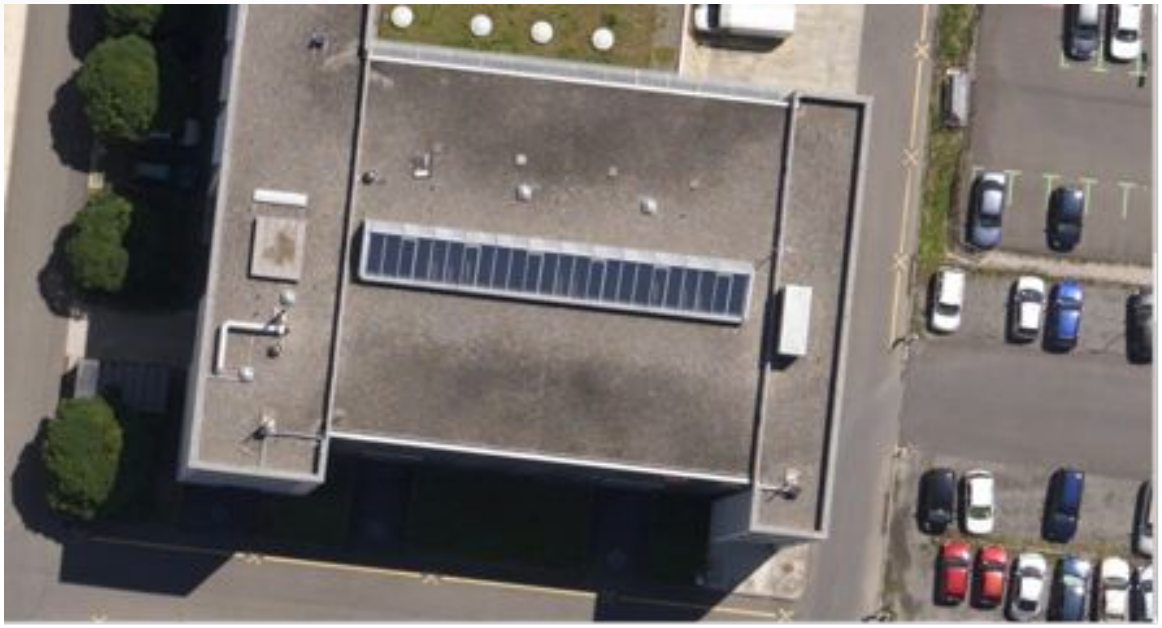

Two Images:

- Consumer camera
  crop of the image
  < 200$

- High end camera
  crop of the image
  (very expensive)

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Two Images:

- High end camera
  full image
  taken from a helicopter

-
-
- Consumer camera
  full image
  taken from a ultra-light drone

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Current approach:

- High end camera, GPS and IMU
- on satelite or airborn platform
- yields excellent geo-reference

- High resolution maps
- expensive

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Accurate low-cost solution:

-
- Low-end camera and GPS
- on ultra-light UAV platform (less 2kg)
- yields approximate geo-reference (5m

- Needs Photogrammetry
- High resolution maps
- low-cost -> on demand, temporal mod

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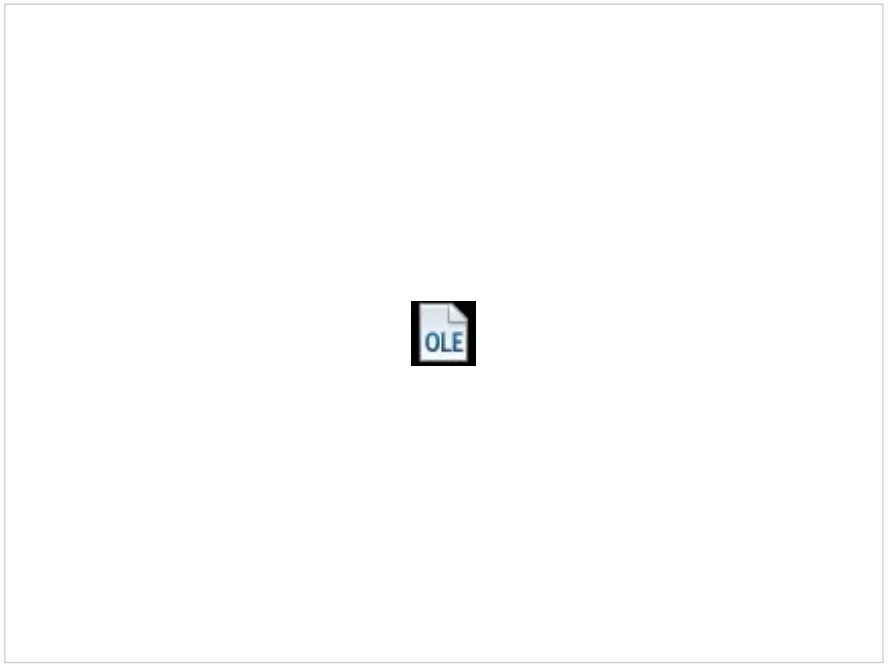
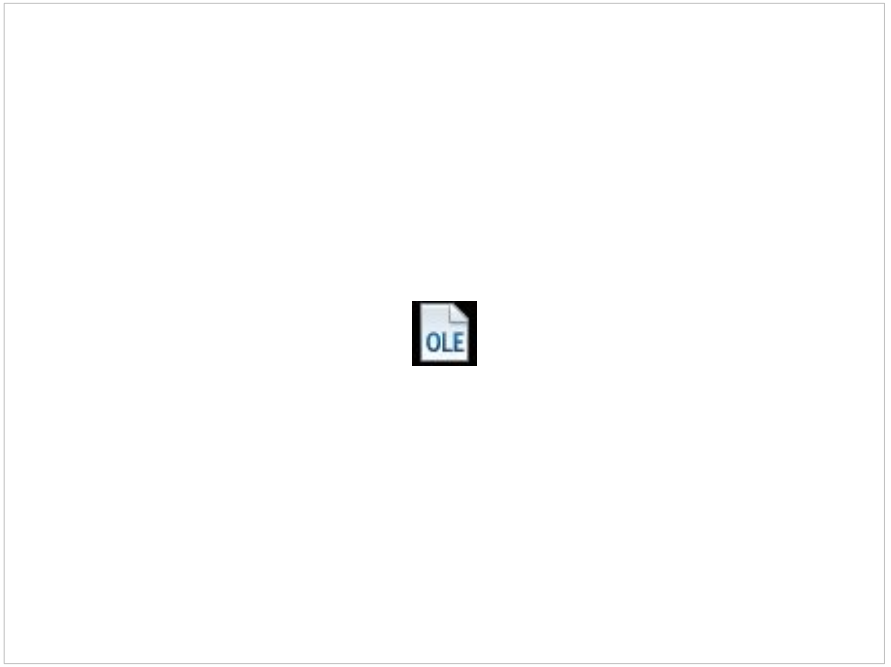


Gatewing x100
~2kg
80km/h
www.gatewing.com



senseFly swinglet
~0.5kg
30km/h
www.sensefly.com

many other UAV’s: e.g. SmartPlanes, Pteryx, Ascending ...

How to get an accurate map from many low resolution images?

Problems:

Because of low UAV payload:

- Inprecise GPS measurements
- Inprecise camera orientation
- Low cost camera optics

Need:

- Robust estimation of internal and external orientation of all images (x, y, z, ω, φ, κ)
- Robust estimation of camera internals - might be different for each flight
- automatic processing - does not require exp


Many low resolution images with inaccureate GPS
instead of a few high resolution images, precisely GEO referenced and with IMU

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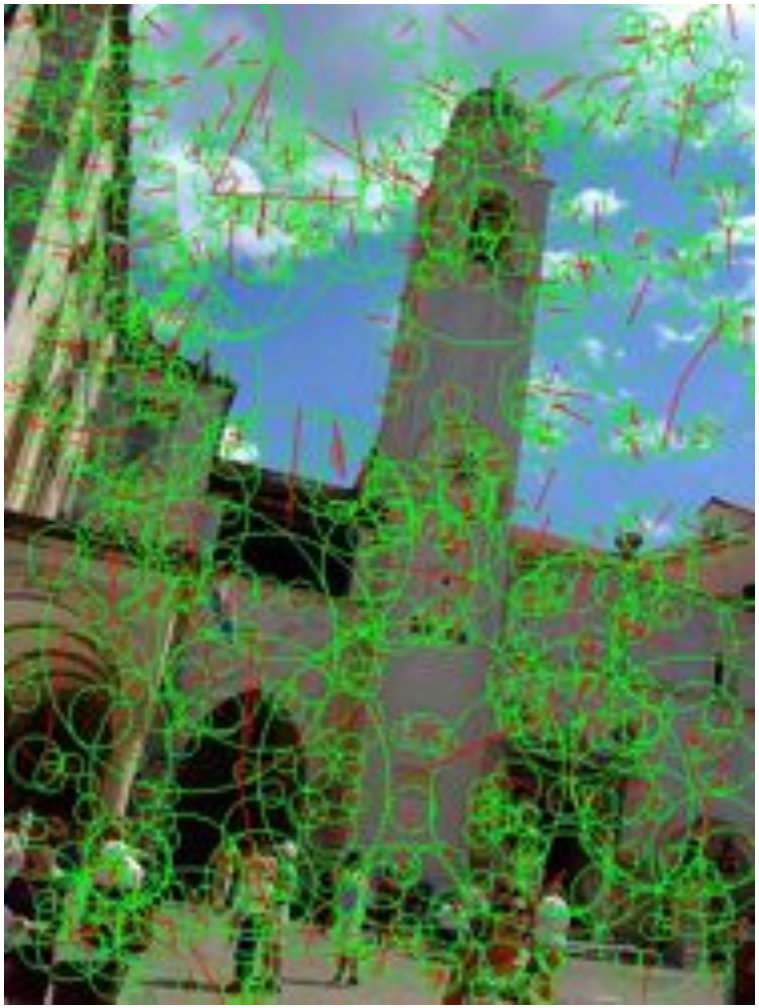
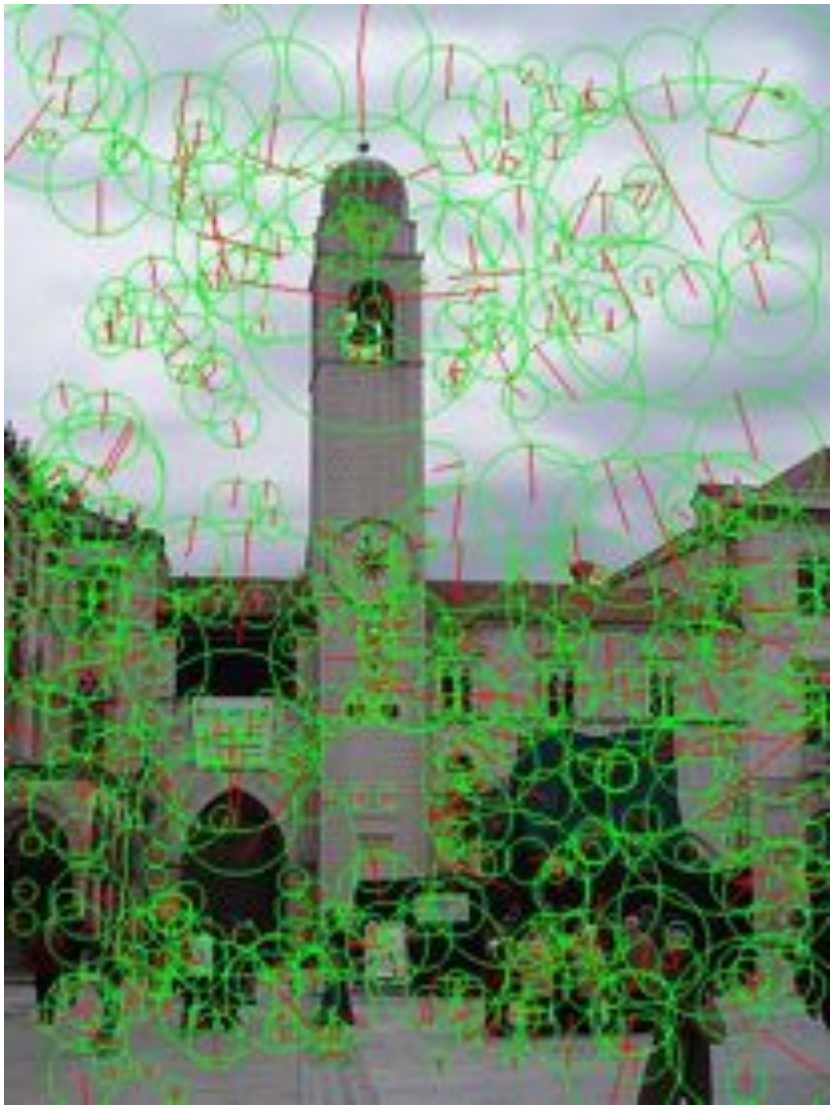
Approach





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Approach

Automatic processing pipeline

-
- invariant keypoint detection
- keypoint descriptor
- keypoint matching
- self-calibration
- bundle adjustment
- dense matching
- dense model building

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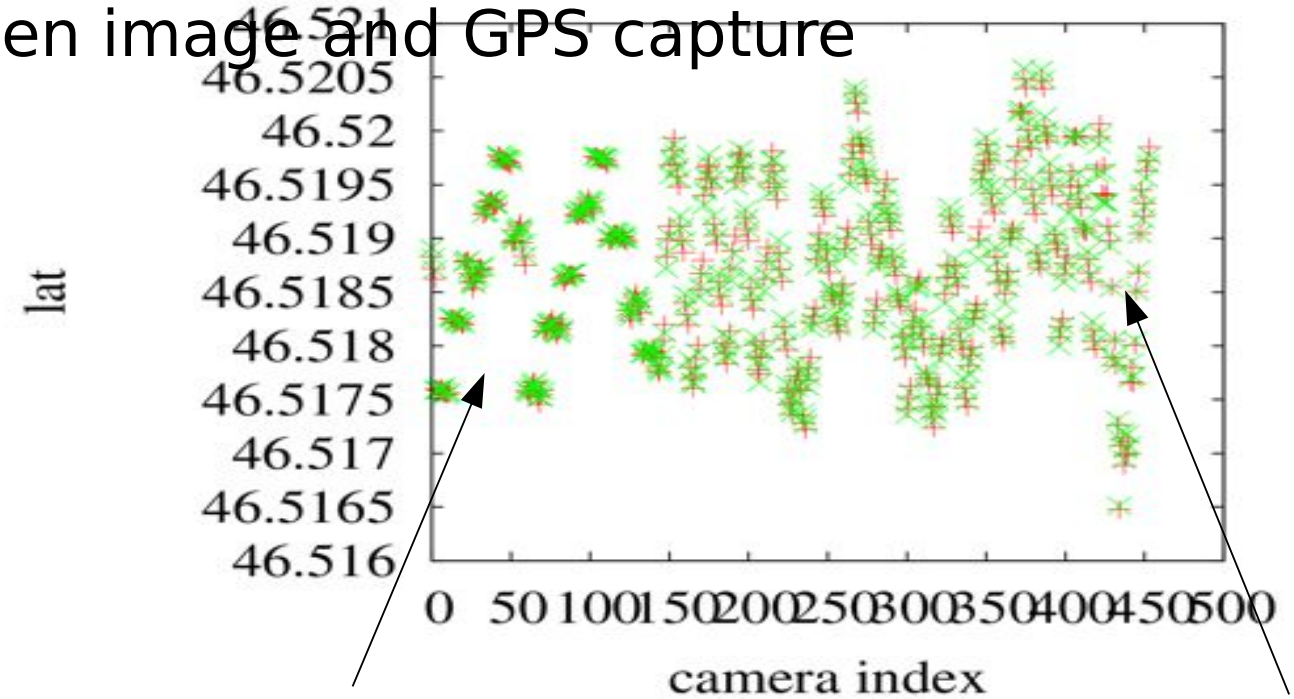
Synchronization errors (Latitude error)
between image and GPS capture



Flight in latitude direction

Flight different latitude direction

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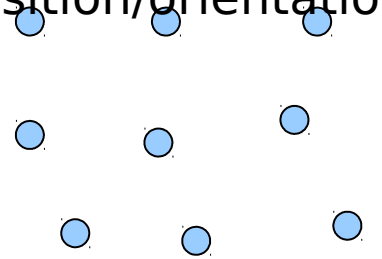
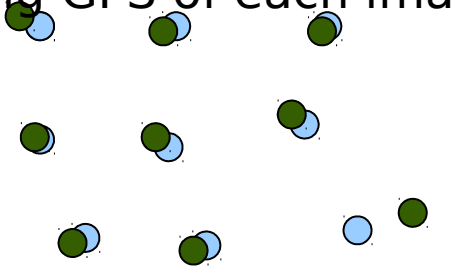
UAV Imagery geo-referencing

Image based RELATIVE Reconstruction of camera position/orientation



rigid transformation
rotation, translation and scale

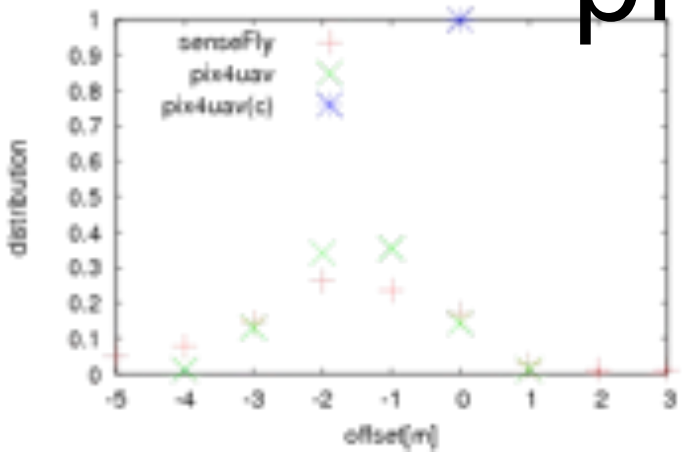
geo-referenced reconstruction using GPS of each image



Robust least square fitting

Accuracy of automated processing

Distribution (PDF) of the camera's



Error in the X camera position by using:

- Raw GPS data (senseFly)
- Hands free Pix4D processing (pix4uav)
- Pix4D processing with Ground Control Points (pix4uav(c))

Raw GPS	4-5m
Pix4uav (hands free)	2-4m
Pix4uav (GCP)	0.1-0.3m (x-y direction) 0.8m (z-direction)
Manual Post Processing	up to 0.05m

Accuracy depends on flight height (ground resolution)

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Gatewing
imagery


Image © 2010 DigitalGlobe
Imagery Date: Aug 2009 50°56'26.10" N 3°48'11.75" E elev 127 ft Eye alt 5256 ft
Google

SenseFly
imagery


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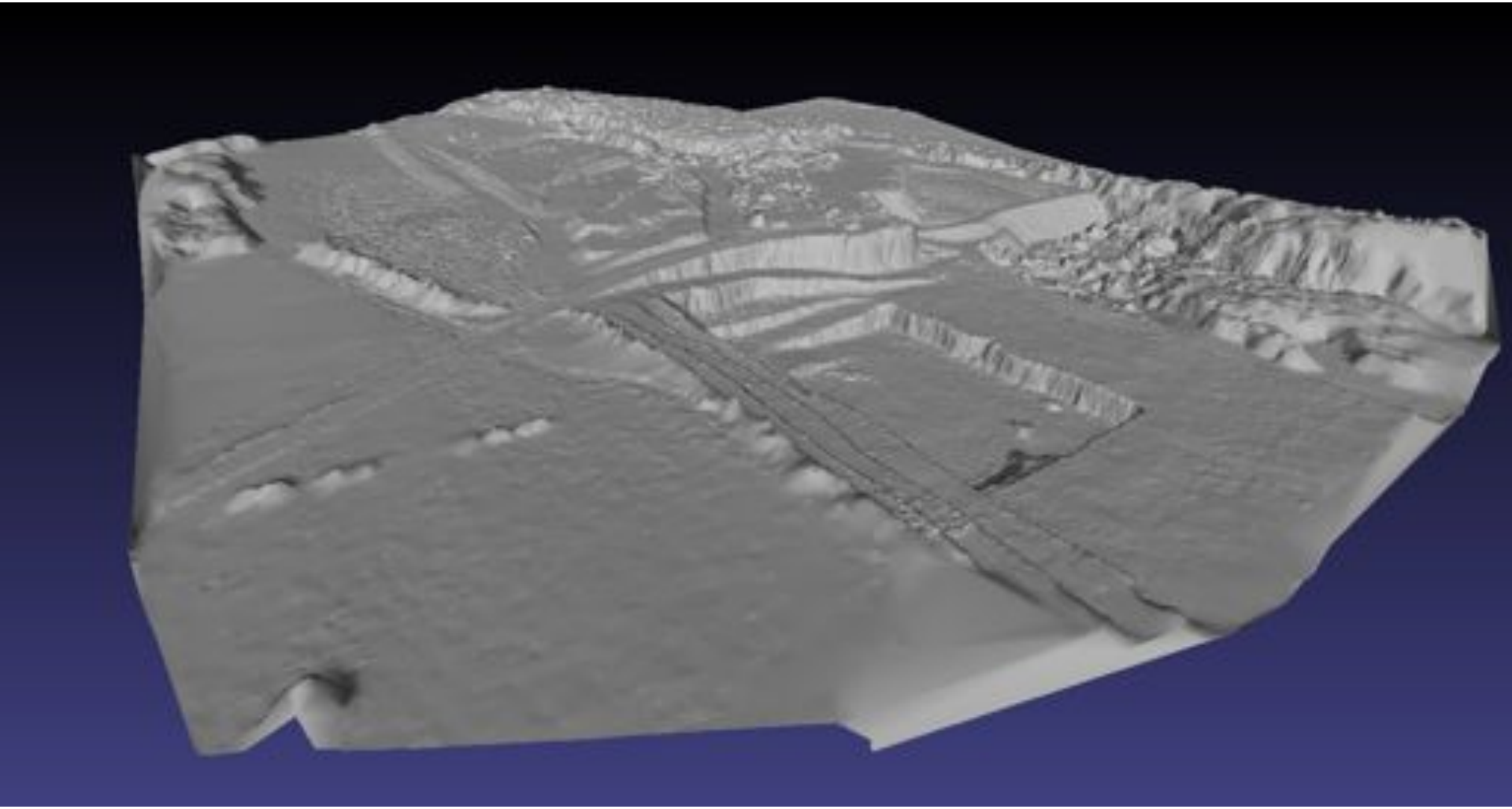
Gatewing imagery

320 images

to produce true ortho



Simplified Building Models

Falcon 8 - flight plan

Sample images

Fully automatic 3D model (textured point clou

Simplified Building Model (e.g. Google earth) obtained by limited manual intervention

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Spatial-temporal Modeling (4D)

- Low-cost image aqcuisition allows to follow an area over time
- Each time instance shows its own 3D structure and appearance
- Pix4D developed photogrametry approaches for accurate registration of different time instances
- Structural change detection becomes possible
  e.g. Glacier development, erosion studies, construction sites

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EPFL
Congress
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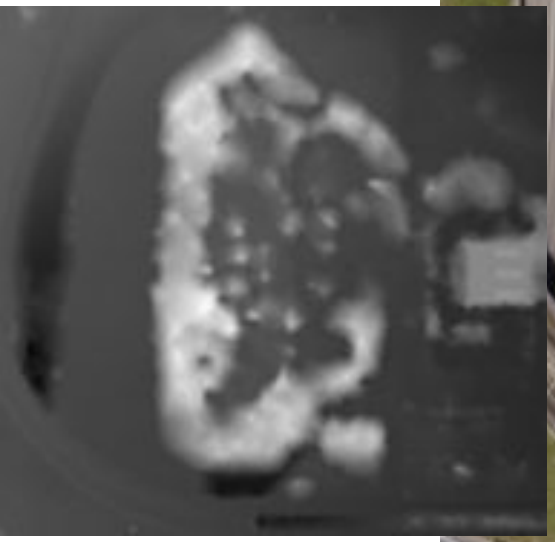
Summer 2010



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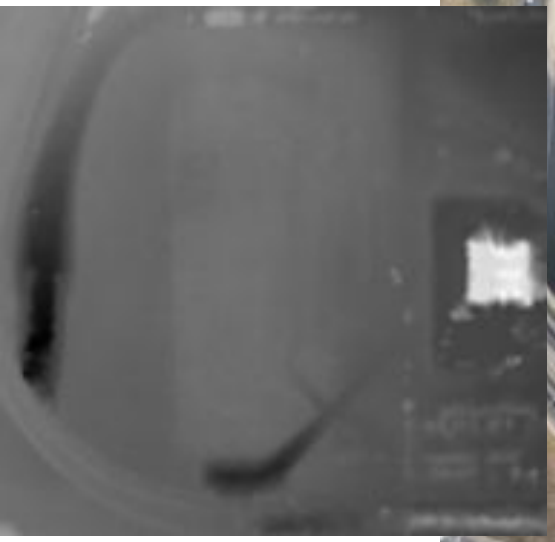
Jan. 2011



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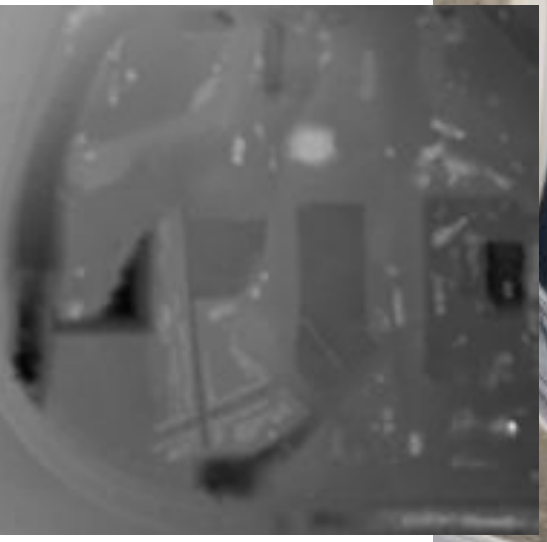

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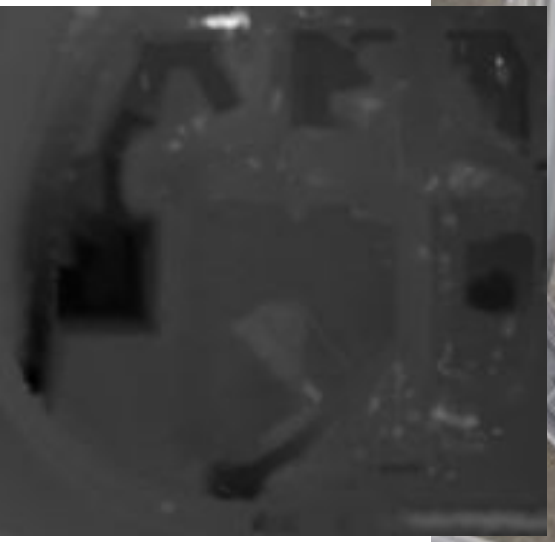

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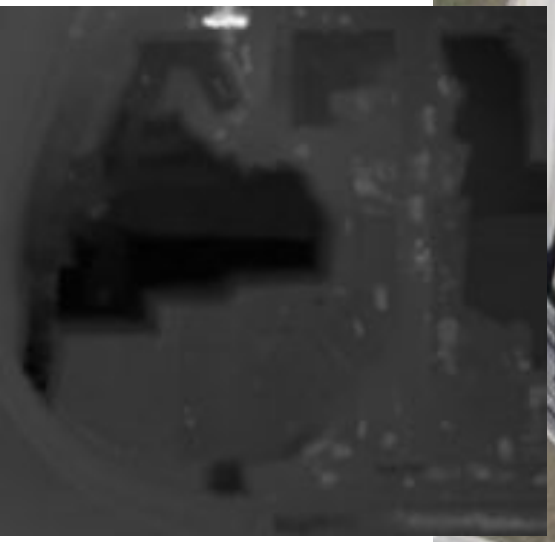

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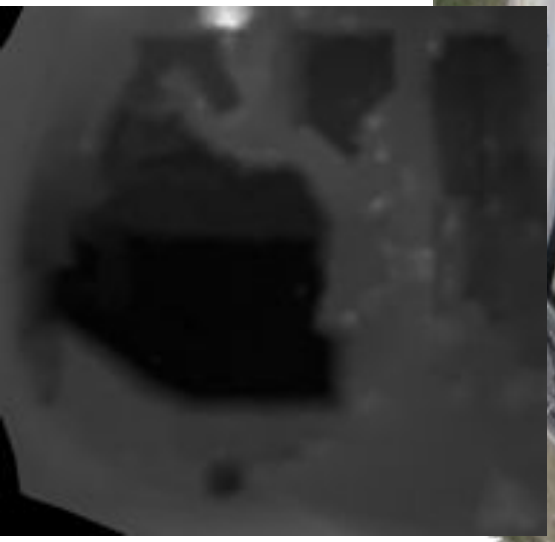

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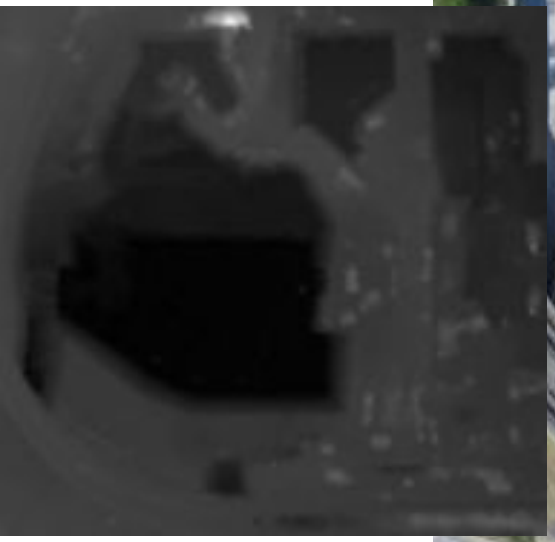
Apr. 2011



04.05.2011

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Thank you!

www.pix4d.com

Acknowledgement: Sensefly, Gatewing, Smartplanes, Ascending, Pteryx,