Simulated bundle adjustments for dynamic, close-range UAS photogrammetry

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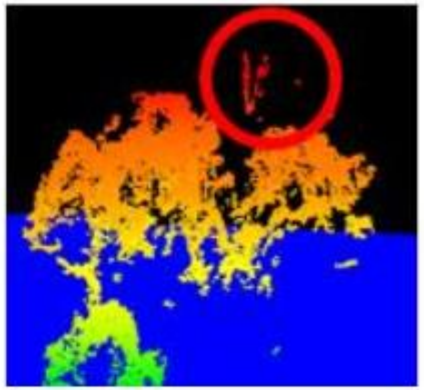
Justification

- We have observed false positive errors in dense-matching point clouds
- One issue is likely the “severely heterogeneous” texture of the forests, which is out of our control
- Another issue may be the geometry of the exposure stations



Justification (2)

- Until now, we have flown our UAS photogrammetric missions as if they were scaled-down versions of a conventional airborne mission
- Those missions are flown with really nice cameras and a small target-height-to-flying-height ratio, e.g.:
  - conventional aerial mission: h=1000 m, average height of targets=15 m, ratio is 1:66
  - UAS mission: h=75 m, average height of targets=15 m, target-to-flying height ratio is 1:5
  - *Relief displacement* and *parallax* play a bigger role in UAS photogrammetry

Justification (3)

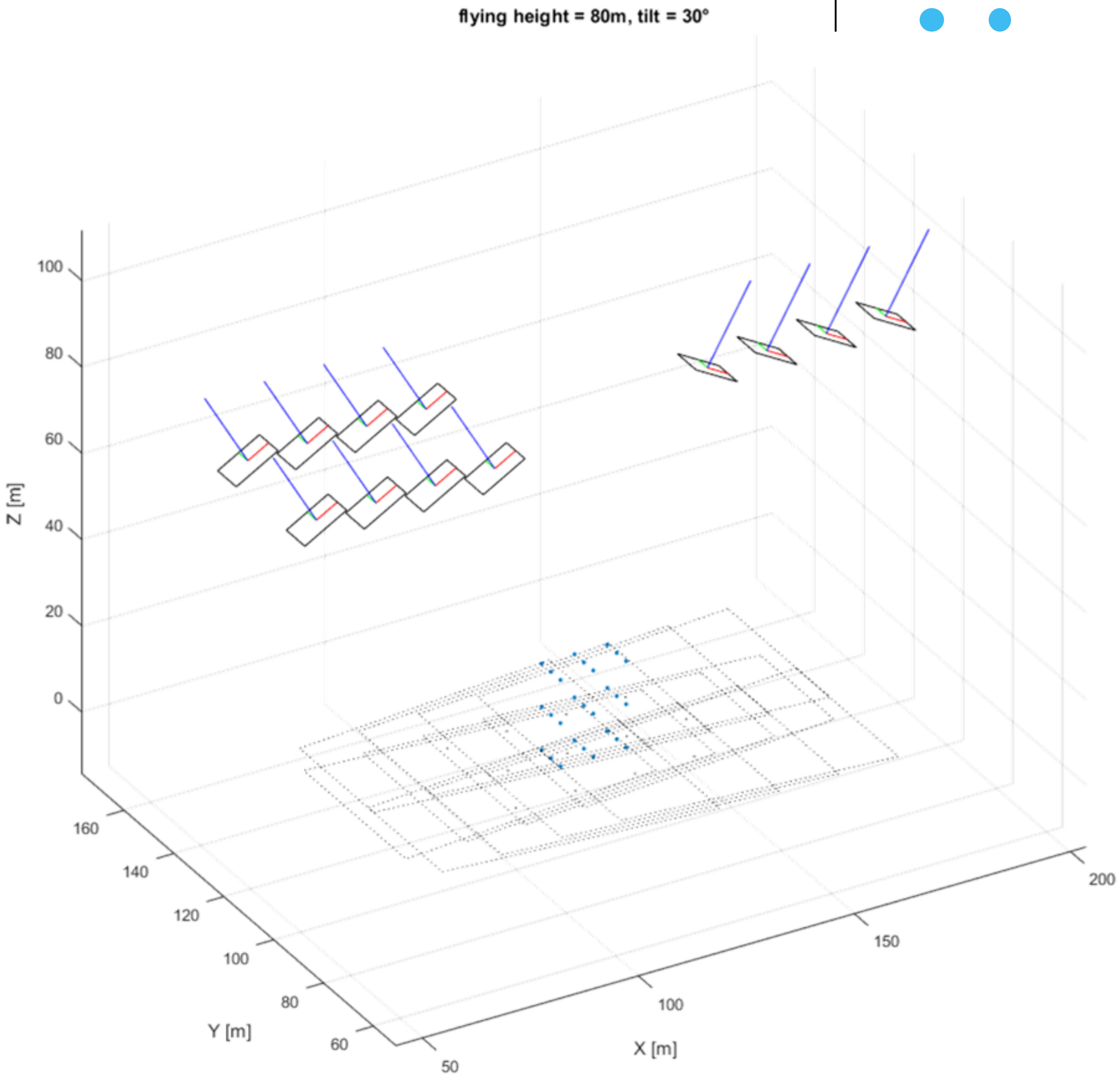
- Perhaps UAS photogrammetry should not be considered as low-altitude aerial photogrammetry, but rather as *dynamic, close-range photogrammetry*
- The goal of this study is to apply close-range photogrammetry considerations to UAS photogrammetry mission planning
- Two main concerns in close-range missions: depth of field, strong geometry between exposure stations (i.e. converging optical axes)
- Both can be achieved through *oblique images*

Purpose

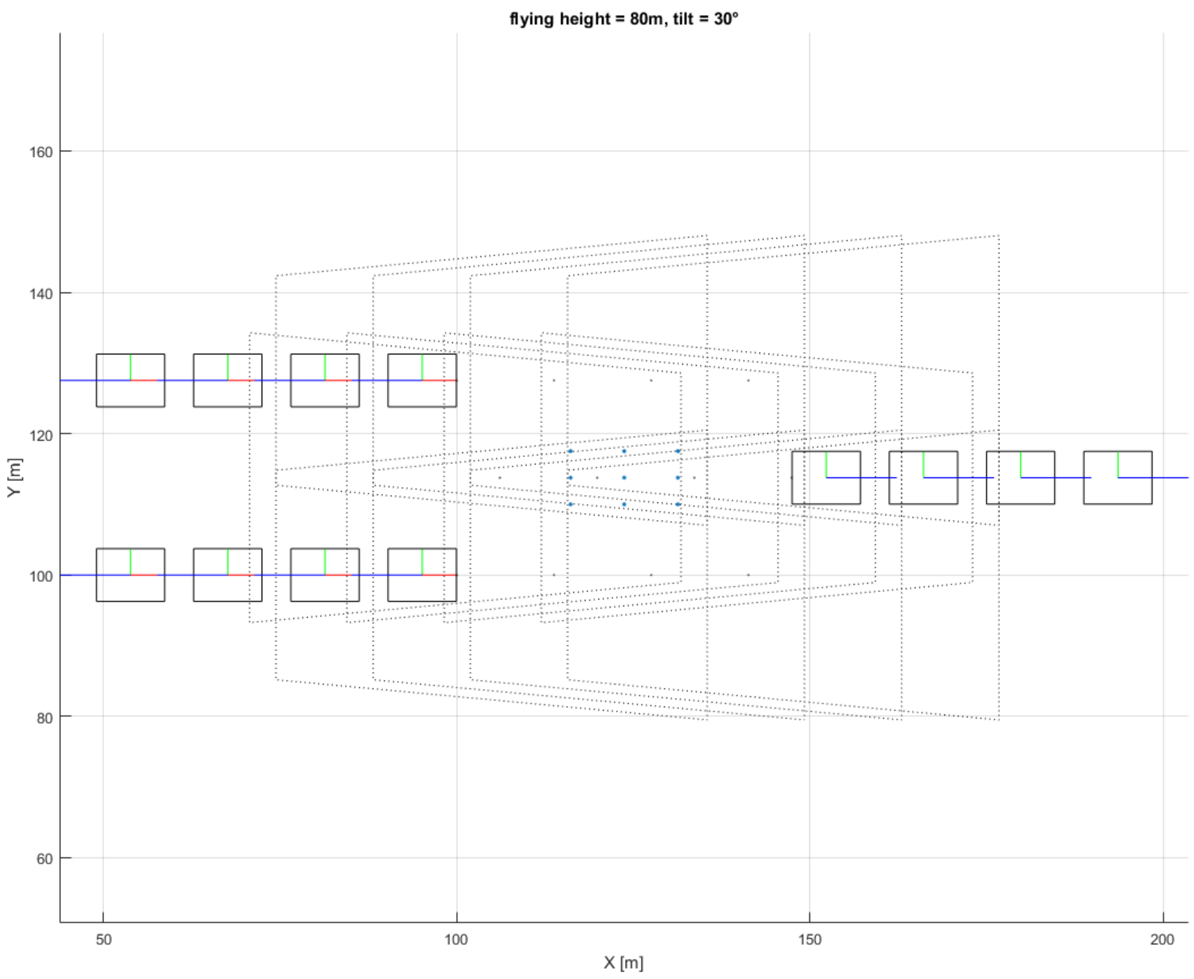
- Write a program (MATLAB) that will simulate a small UAS photogrammetry mission
- Perform a bundle adjustment on the outputs of this program at varying tilts, focal lengths, and flying heights
- Compare the statistics from each bundle adjustment to determine how much tilt (if any) can improve the accuracy of the bundle adjustment while allowing for an efficient mission

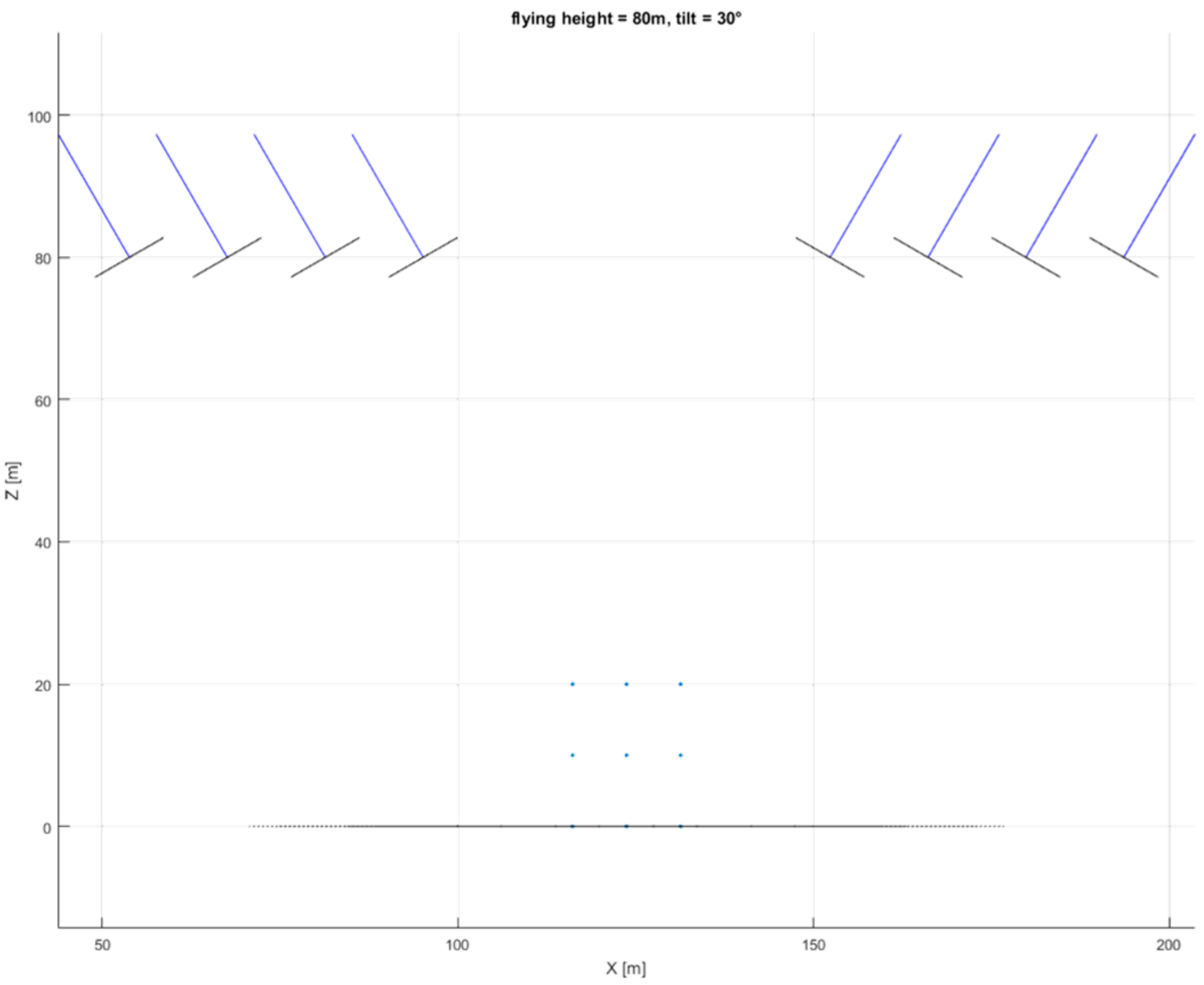
Mission simulation

- Input: endlap, sidelap, flying height, tilt
- Camera parameters of Canon EOS Rebel SL1 (f=25mm and 40 mm)
- Three strips of four photos each over a 3x3x3 array of points
- Goal: virtual images from all 12 exposure stations; used as input for existing BA program



Mission simulation (2)





Mission simulation (3)

- Airbase for *low* oblique images:

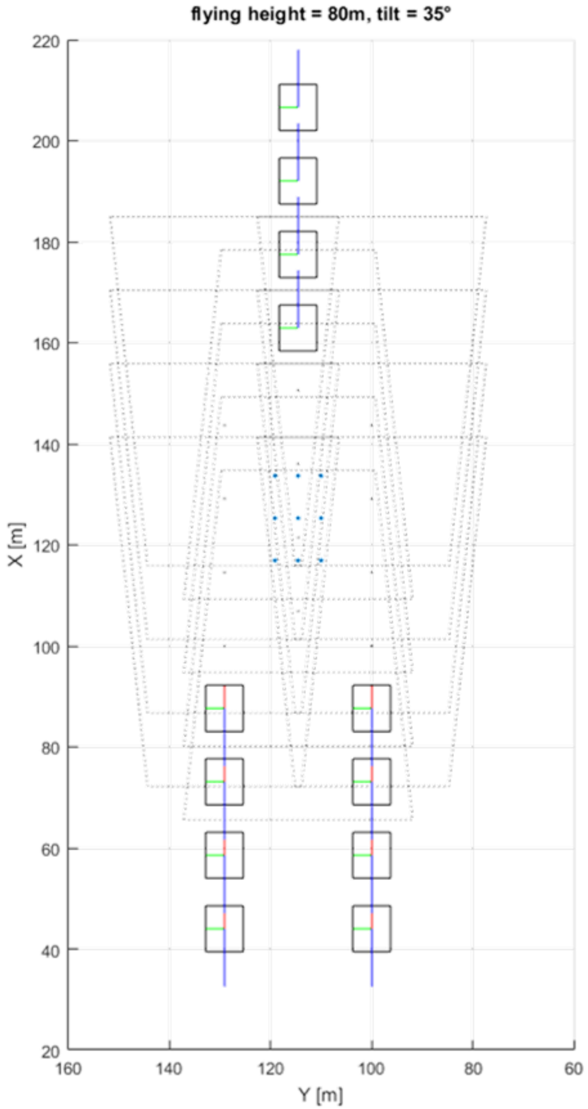
$$B = H' \left[\tan\left(t + \frac{\phi}{2}\right) - \tan\left(t - \frac{\phi}{2}\right) \right] (1 - E)$$

This formula is weak because the domain of tangent is not continuous.

- Airwidth:

$$W = H' \frac{w}{f \cos t} (1 - S)$$

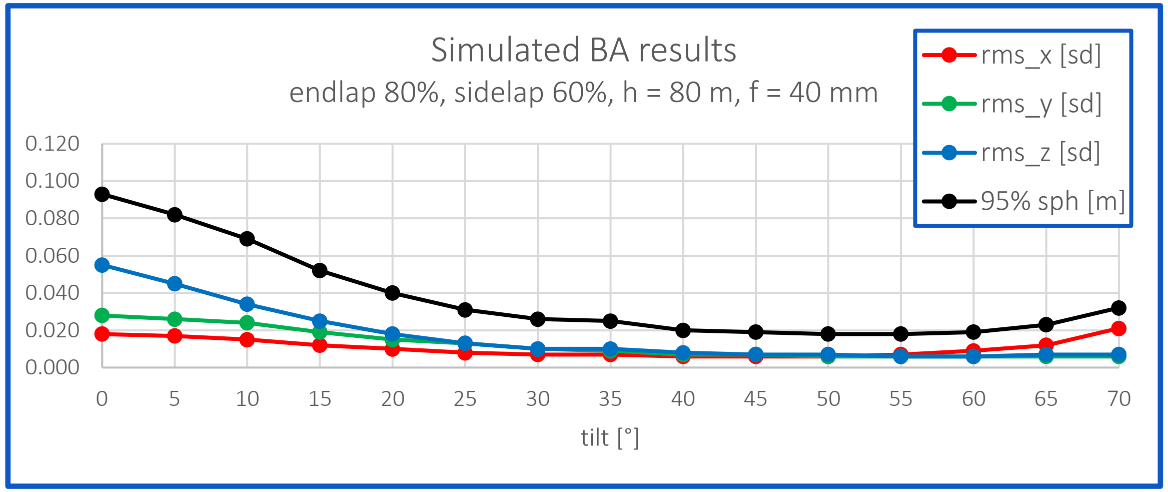
t = tilt, ϕ = FOV, w = format width, f = focal length
E = endlap percentage, S = sidelap percentage estimate*



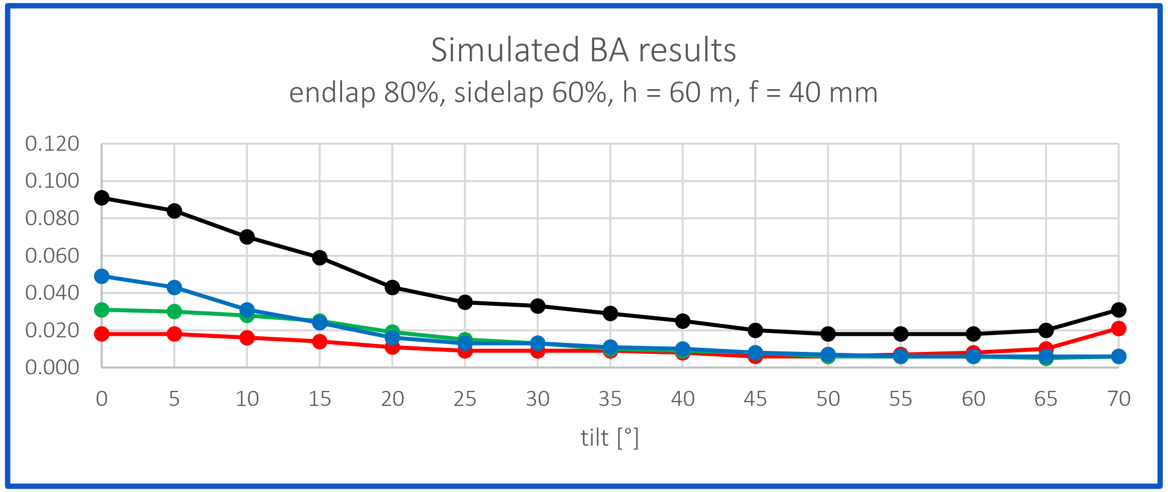
Mission simulation (4)

- Each exposure station is treated as an ideal pinhole camera; not here to test self-calibration
- 0.5 pixel Gaussian noise is added to the back-projected points (not sure if this step was necessary)
- Final output of missionSim() is a text file that can be read by BUN2013.exe

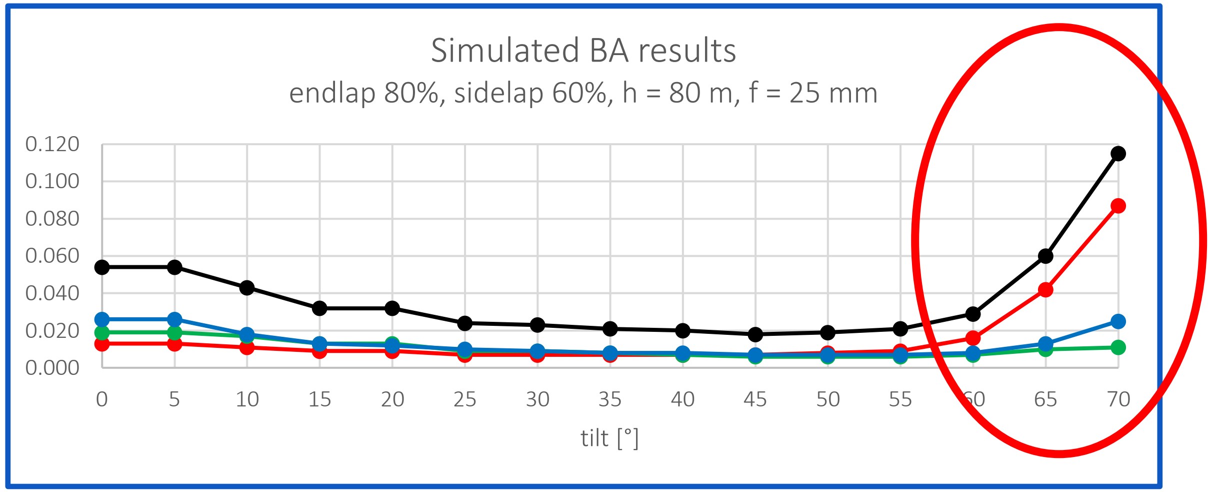
Results



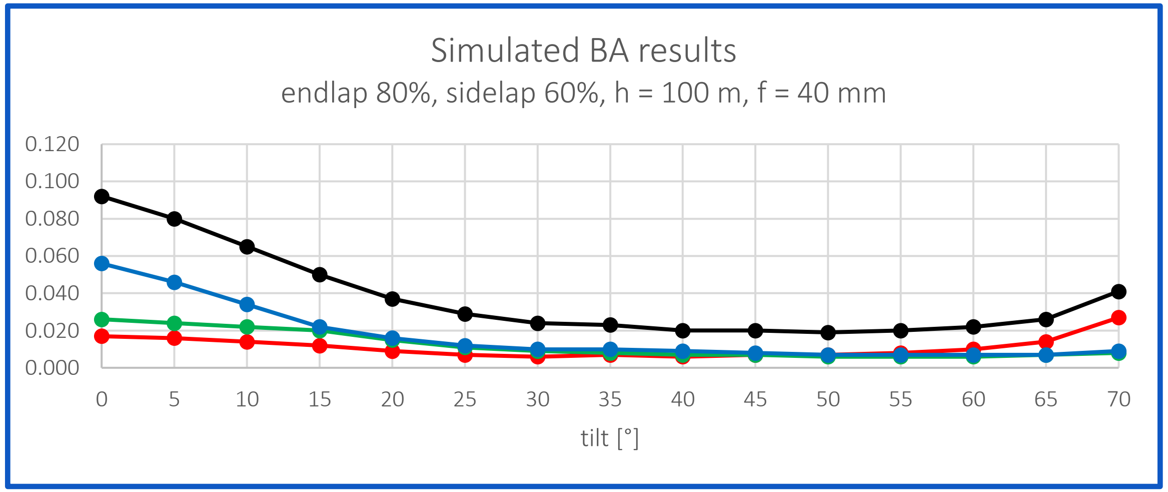
Simulated BA results
endlap 80%, sidelap 60%, h = 80 m, f = 40 mm
rms_x [sd]
rms_y [sd]
rms_z [sd]
95% sph [m]
0.120
0.100
0.080
0.060
0.040
0.020
0.000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70
tilt [°]



Simulated BA results
endlap 80%, sidelap 60%, h = 60 m, f = 40 mm
0.120
0.100
0.080
0.060
0.040
0.020
0.000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70
tilt [°]



Simulated BA results
endlap 80%, sidelap 60%, h = 80 m, f = 25 mm
0.120
0.100
0.080
0.060
0.040
0.020
0.000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70
tilt [°]



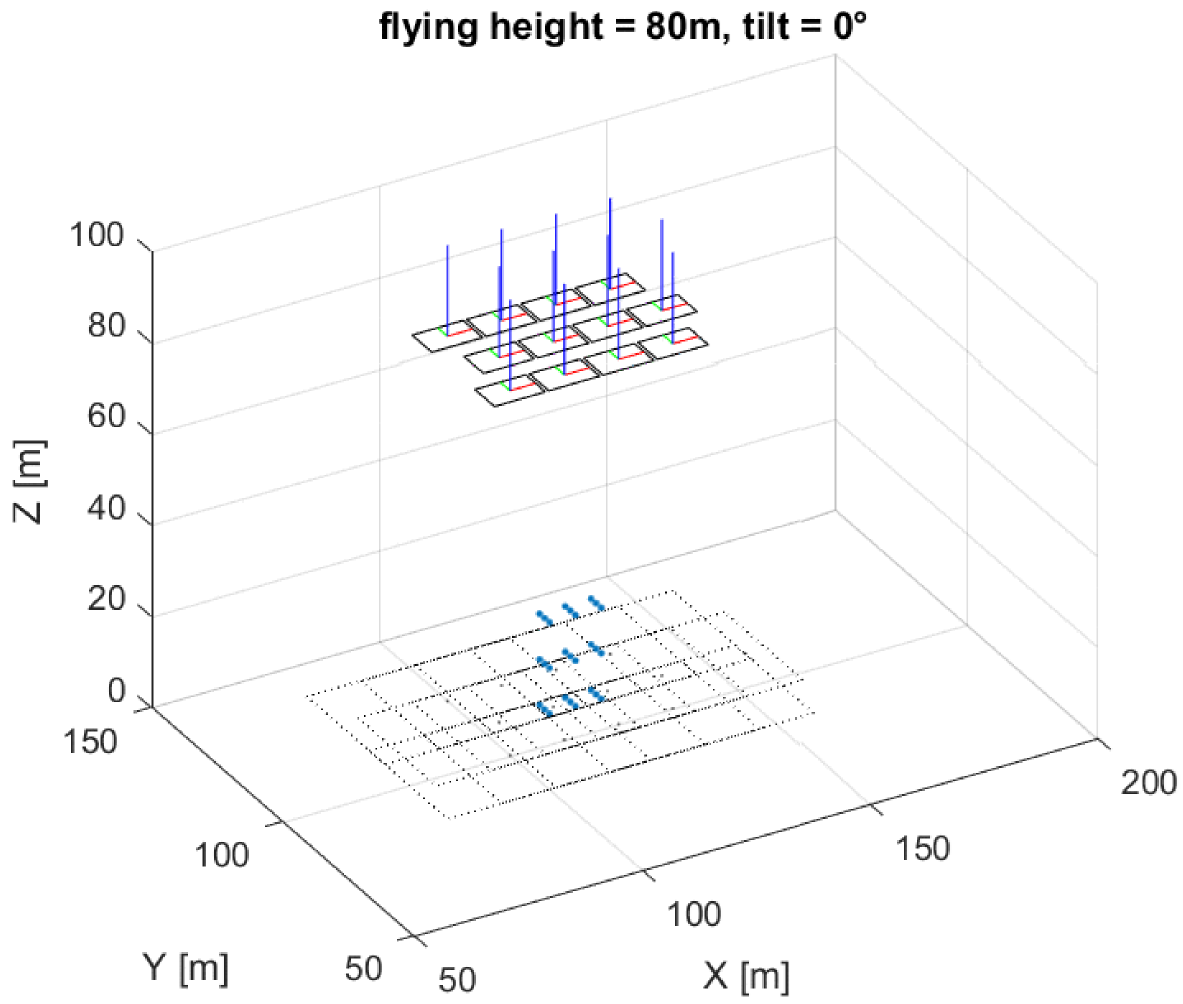
Simulated BA results
endlap 80%, sidelap 60%, h = 100 m, f = 40 mm
0.120
0.100
0.080
0.060
0.040
0.020
0.000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70
tilt [°]

Results (2)

- The RMS of the standard deviations in X, Y, and Z, as well as the 95% spherical error, decreases as tilt increases (up to a point)
- RMS of standard deviation in X (i.e., direction of travel) begins to increase sharply as tilt (and subsequently airbase) gets too long
- High oblique images (circled in red, previous slide) cause RMS sd_X and subsequently 95% spherical error to rise sharply

Discussion

- Tilt improves geometry and provides better results for BA
- However, too much tilt can add to flight time by “offsetting” the flight lines (right)
- A balance must be maintained between good geometry and flight line length (i.e. flight time)



Fin.

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