Rolling Shutter Effect in UAS, and Impact on Accuracy

ASPRS UAS Symposium 2016

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Pix4D today

- Drone mapping Software
- Aerial / Terrestrial mapping
- 3D modeling

- Headquarters in Lausanne (CH)
- Pix4D Inc. San Francisco (USA)
- Office Shanghai (China)

- 70 employees
- More than 140 partners worldwide
- 8,000 desktop projects per day
- 50+ projects on cloud every day

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Consumer Drones – Rolling shutter

	Parrot Bebop2	DJI Phantom3
Price $	~ $ 500	~ $ 1.000
Sensor	?	6.3 x 4.72 mm
Image size	4096x3072	4000x3000
Example image		
Flight time	25min	23min
Weight	500g	1.280g
Picture		

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Prosumer Drones – Rolling shutter

	Parrot Bebop2	DJI Phantom3	DJI Inspire1 x3	DJI Inspire1 x5
Price $	~ $ 500	~ $ 1.000	~ $ 3.000	~ $ 5.000
Sensor	?	6.3 x 4.72 mm	6.17 x 4.55 mm	17.3 x 13.0 mm
Image size	4096x3072	4000x3000	4000x3000	4608x3456
Example image				
Flight time	25min	23min	18min (TB47) battery	16min (TB47 battery)
Weight	500g	1.280g	2.935g	3.500g
Picture				

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Common shutter types

- Mechanical rolling shutters – most DSLR systems
- Mechanical global shutters – most compact cameras and photogrammetric cameras
- Electronic global shutter – older DSLRs with CCD sensors, some specialized recent cameras
- Electronic rolling shutters – smartphones, GoPro Hero, Phantom 2 & 3, videos on DSLRs and consumer cameras

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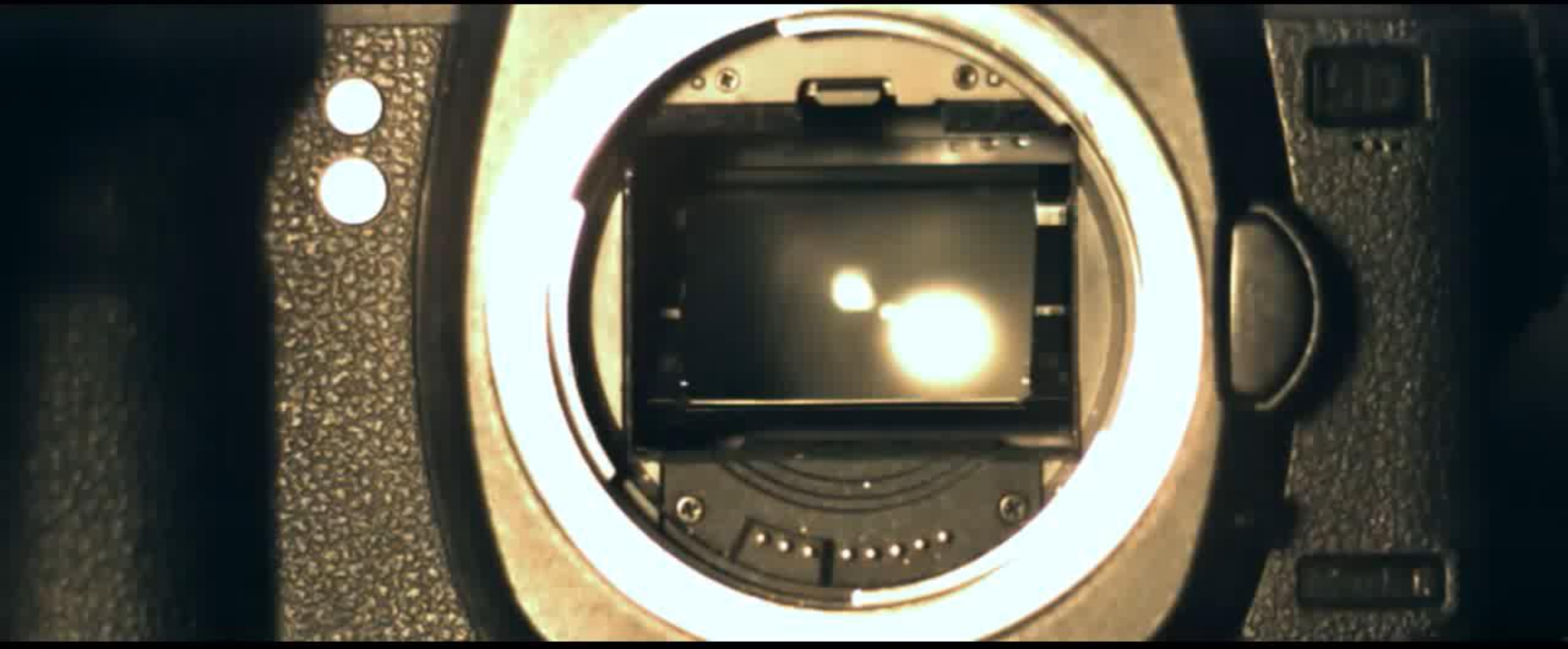
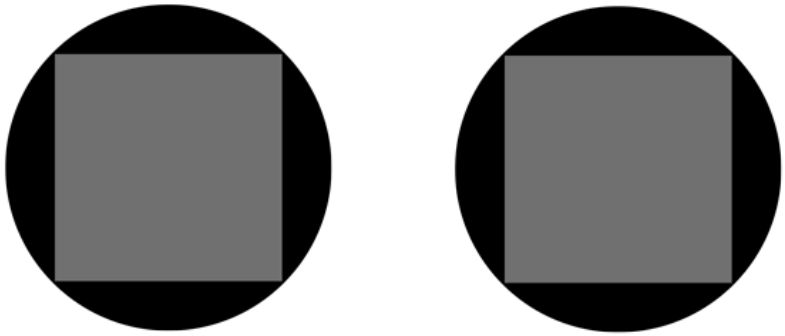
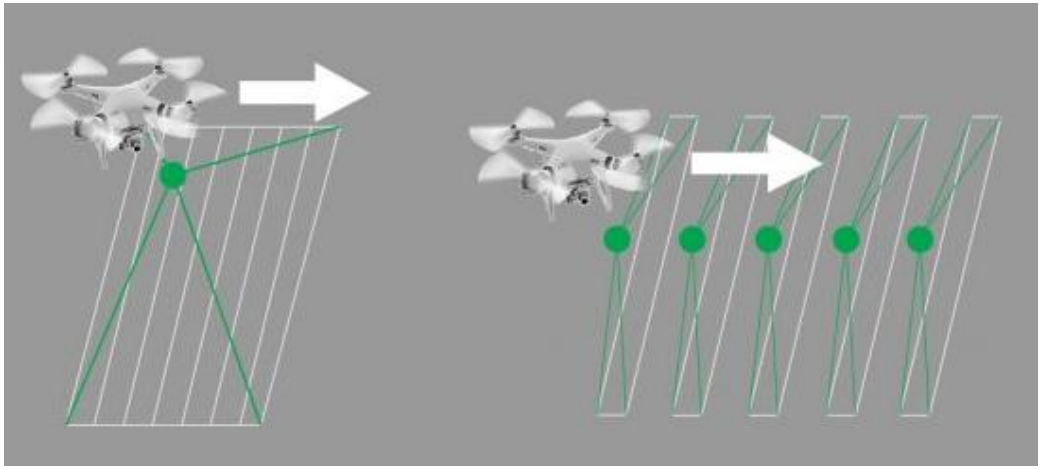
Regular speed



1/200 sec shutter speed

What is Rolling Shutter





- Scan line capture of the image
- Leads to geometric distortions when cameras move
- Geometric distortion can be modelled with Pix4Dmapper

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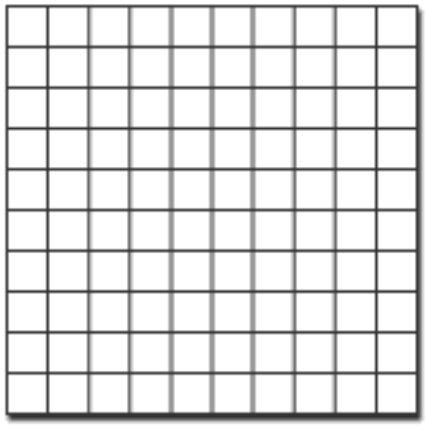
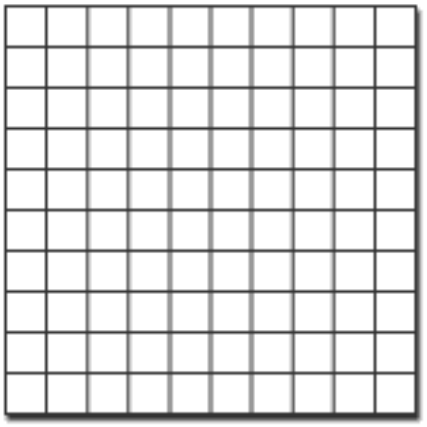
Shutter and Man



Final Image



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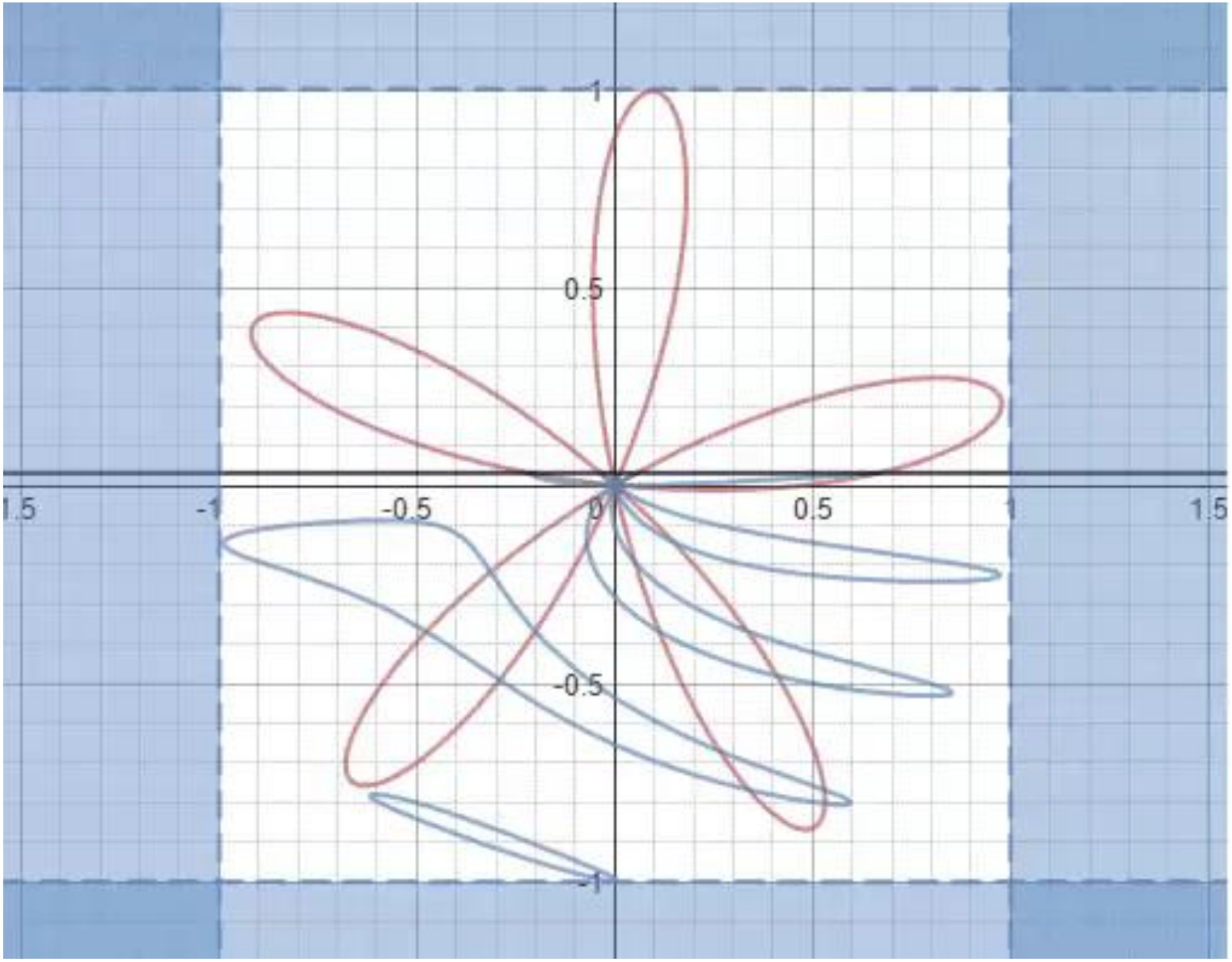

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Rolling shutter

- Cheaper
- Position of the image is a **path C(t)**
- **Path needs to be estimated to get highest accuracy**

$$C(t) = C_0 + t\Delta c$$

Global shutter

- Additional mechanical shutter
- Position of the image is a **point C**

$$C = C_0$$

Pix4D is modeling rolling shutter cameras

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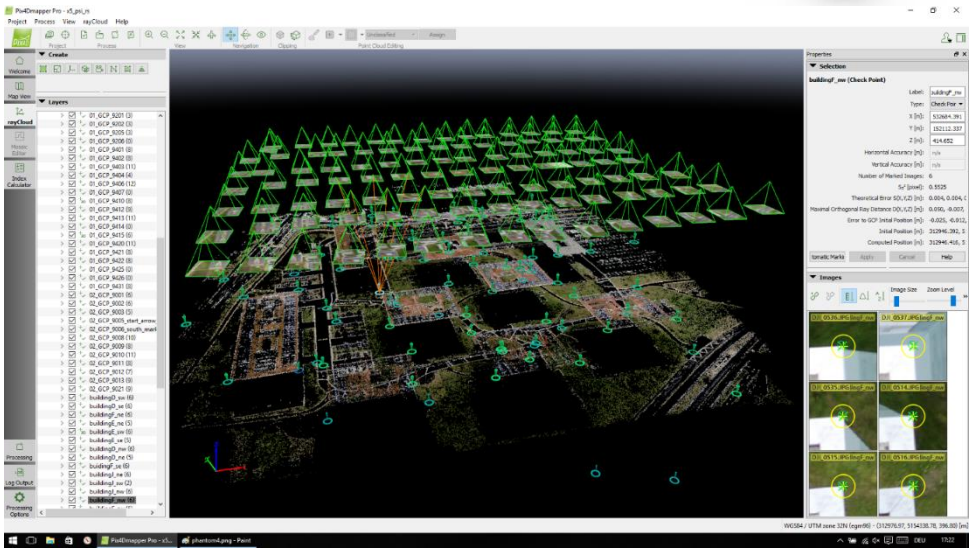
Benchmark tools



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Experiments – EPFL innovation park

- Different drones at different speed
- 6 GCP's
- 6 verification points

- Compare results with and without rolling shutter modelling

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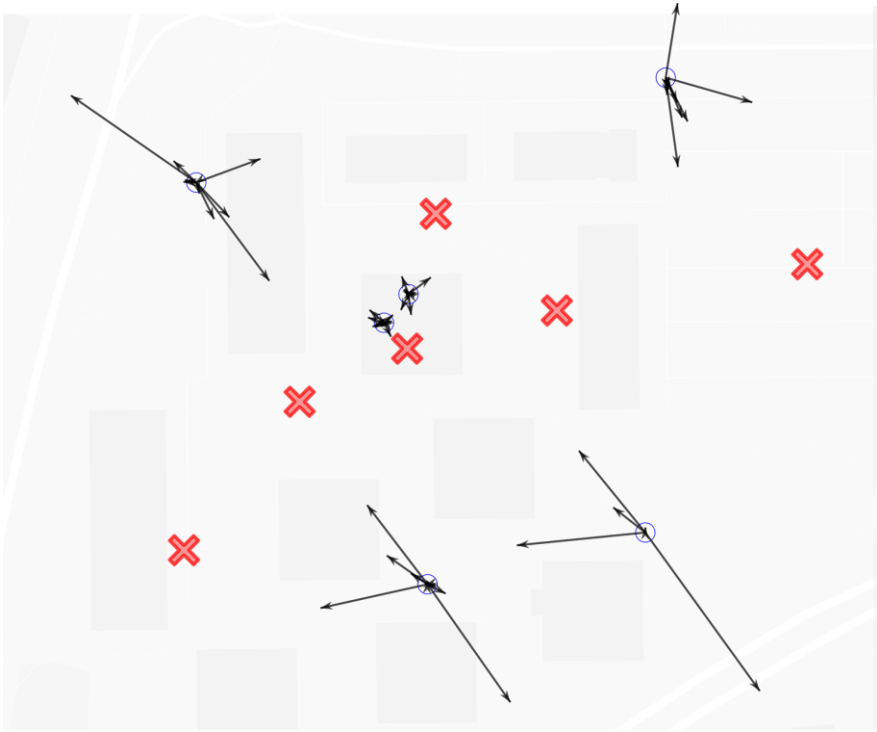
Accuracy Global Shutter vs Rolling Shutter



Global shutter model

Rolling shutter model

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Accuracy

Camera model	Speed [m/s]	Reprojection error [pix]	Validation GCPs	RMS X [cm]	RMS Y [cm]	RMS Z [cm]
Phantom 2 Vision+	8	0.24	6	13.5	17.9	7.1
Phantom 2 Vision+ RS		0.23		2.3	3.7	1.4
Phantom 2 Vision+	4	0.24	6	7.9	8.2	7.4
Phantom 2 Vision+ RS		0.24		3.6	2.9	4.6
Phantom 2 Vision+	1	0.24	5	1.8	3.6	5.5
Phantom 2 Vision+ RS		0.24		2.6	3.3	6.6
Inspire 1	8	0.28	5	4.2	4.4	10.2
Inspire 1 RS		0.19		2.2	2.5	6.4
Inspire 1	4	0.23	5	2.1	1.8	8.6
Inspire 1 RS		0.20		2.7	2.4	7.4
Inspire 1	1	0.20	5	2.7	1.9	8.3
Inspire 1 RS		0.20		3.2	2.8	7.5
eBee	8–13	0.23	6	1.3	1.5	3.2
eBee RS		0.23		1.1	1.7	3.2

Table 3. Comparison of the camera models with and without rolling shutter (RS) block adjustment for various cameras and flight speeds recorded at our test site. Of the 12 GCPs available, 6 were used for the calibration and 5-6 were used as validation GCPs (one was sometimes occluded). The GSD of the datasets is always around $2.85\,\mathrm{cm}$. The RMS error is reported on the validation GCPs. For the RMS errors, the following color coding was applied: horizontal X and Y axes: green ≤ 2 GSD $<$ orange ≤ 3 GSD $<$ red; vertical Z axis: green ≤ 3 GSD $<$ orange ≤ 4 GSD $<$ red. The large area dataset is the one shown in Fig. 11

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- Rolling shutter modelling improves results for all rolling shutter cameras
- Achieve usual 2-3 pixel accuracies

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- Rolling shutter modelling does not disturb accuracies of global shutters cameras

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eBee	8–13	0.23	6	1.3	1.5	3.2
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- rolling shutter modelling improves with drone speed

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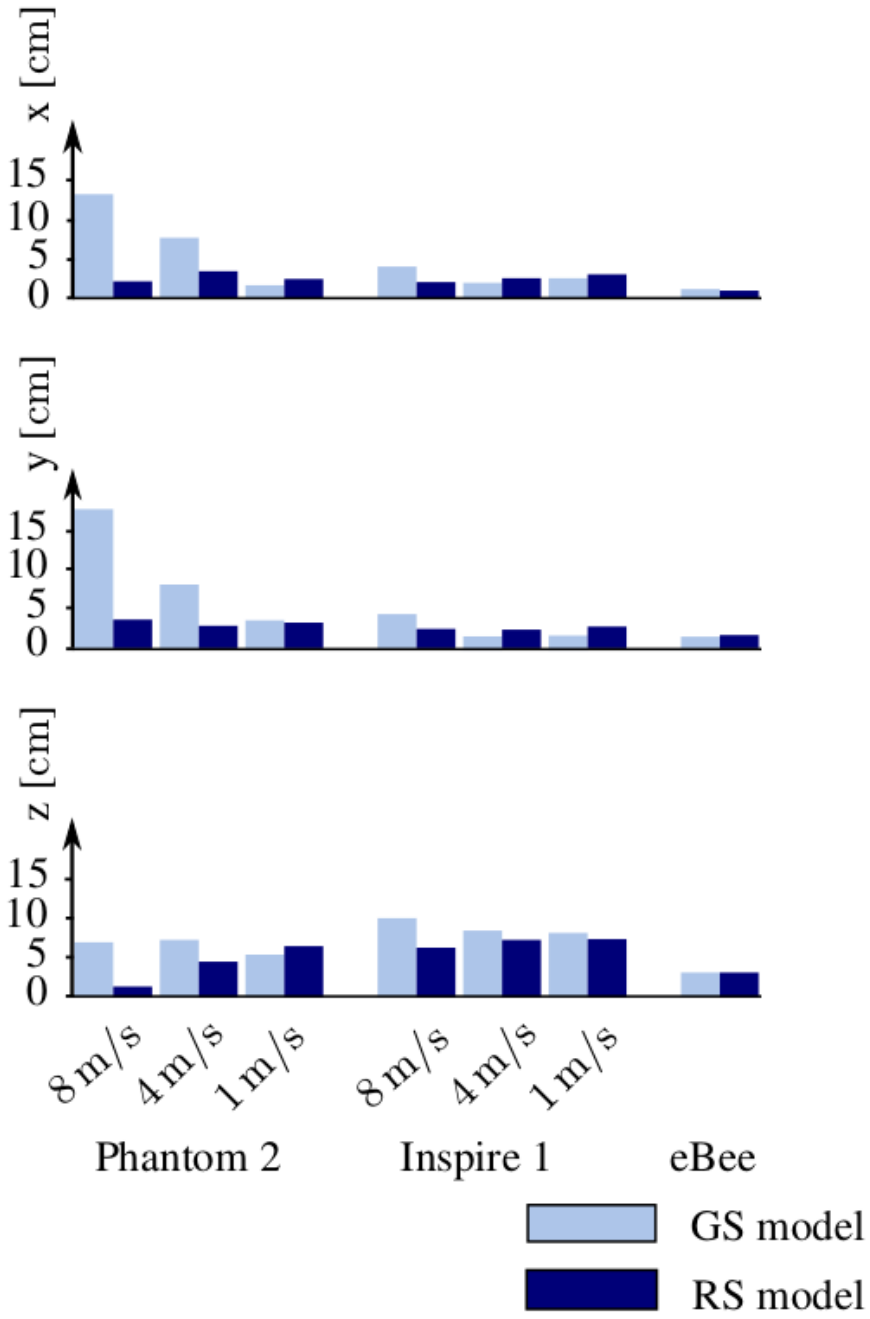
Accuracy



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Conclusions

- Rolling shutter modelling inside Pix4Dmapper
- Increase accuracy for rolling shutter cameras
- Allows to fly drones with a higher speed without loosing accuracy
- One drone battery can cover a larger area

https://pix4d.com/rolling-shutter-correction/

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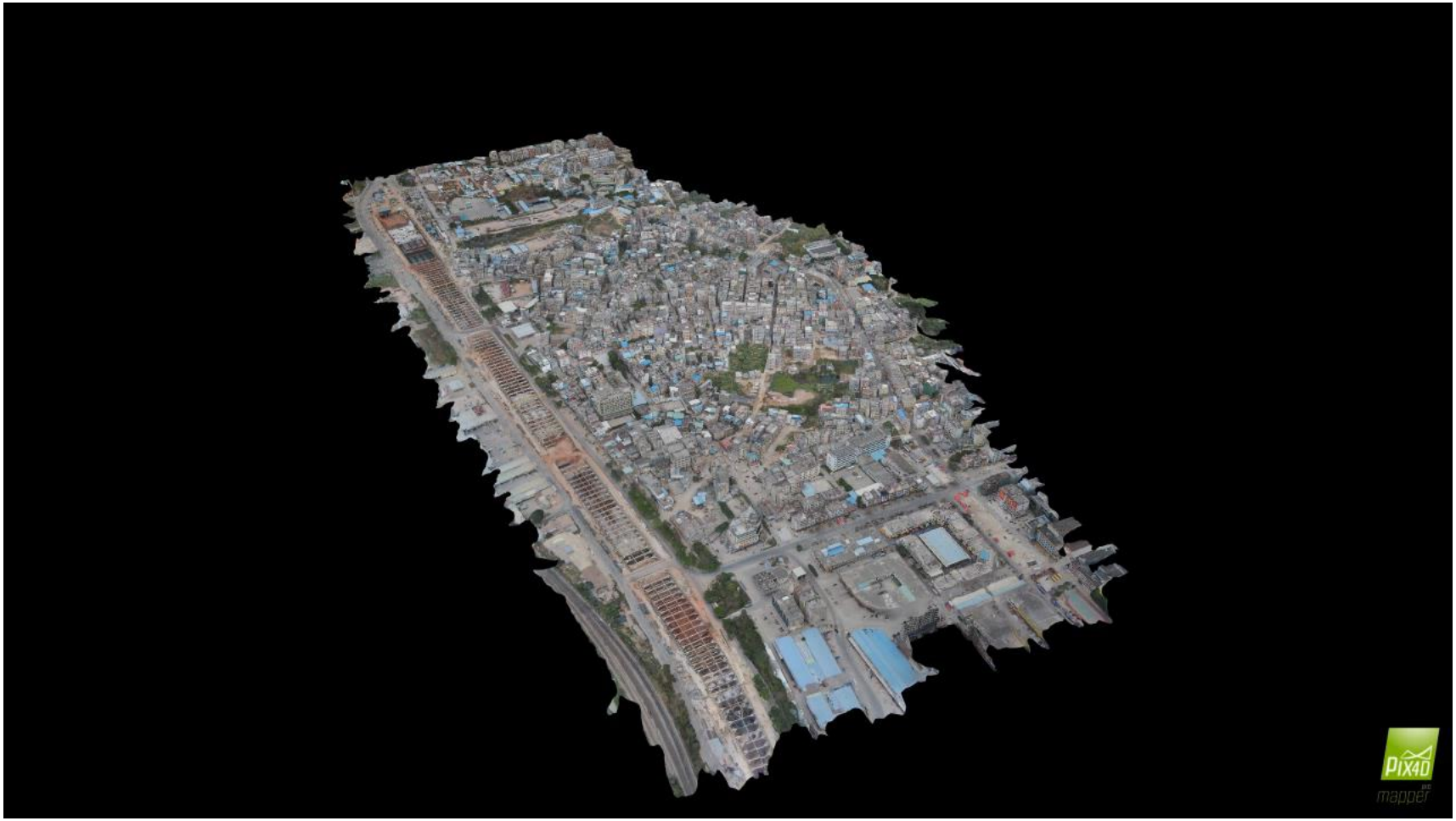
Compare different consumer drones

https://www.youtube.com/watch?v=1fDtOxKhxzc

Example – Phanton 2 Vision+

13 flights – 1800 images
https://www.youtube.com/watch?v=lYOsfXdHqiM



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Thank you!

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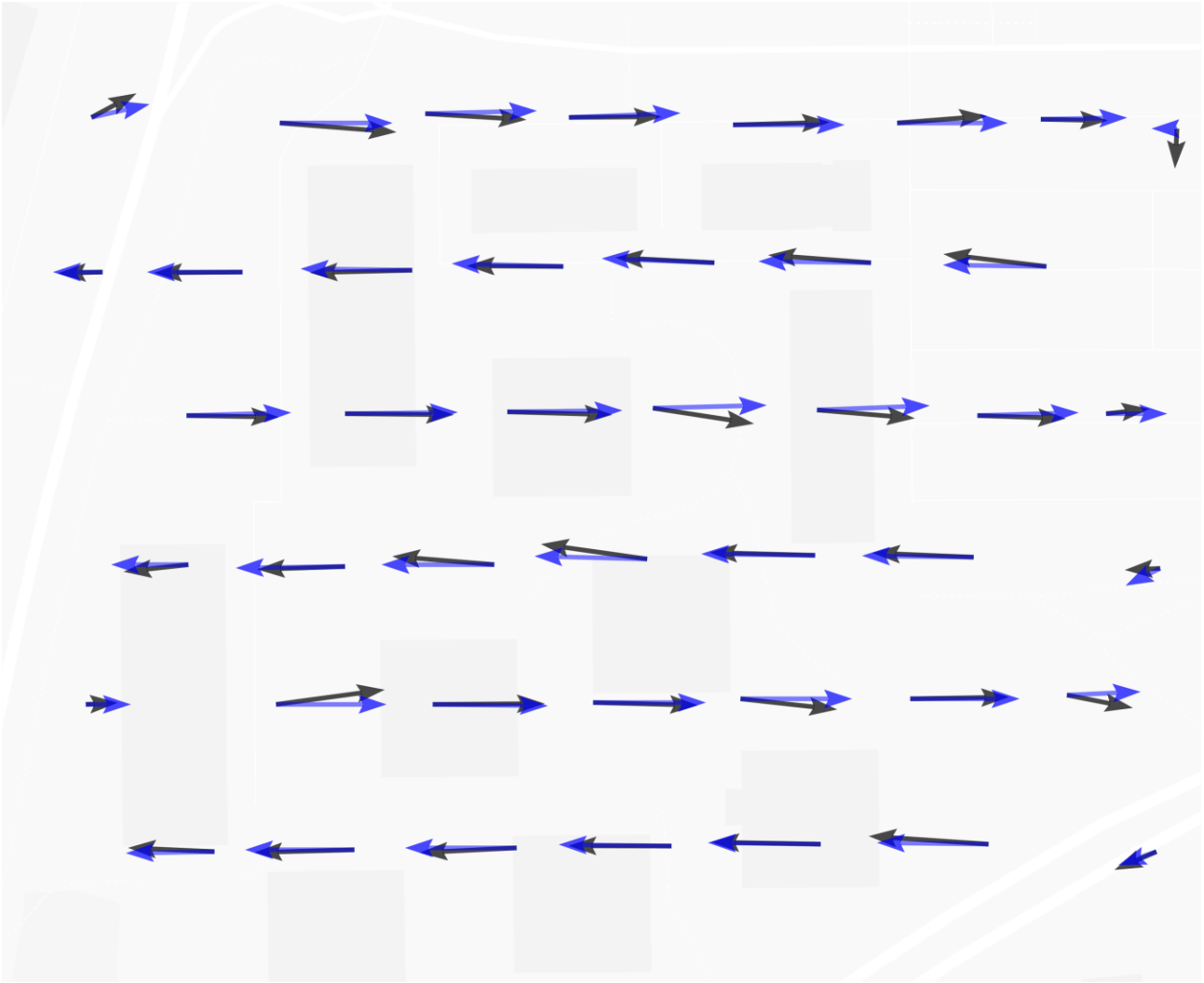
Obtain the drone speed from images



Blue: From drone's telemetry
Black: Rolling Shutter model

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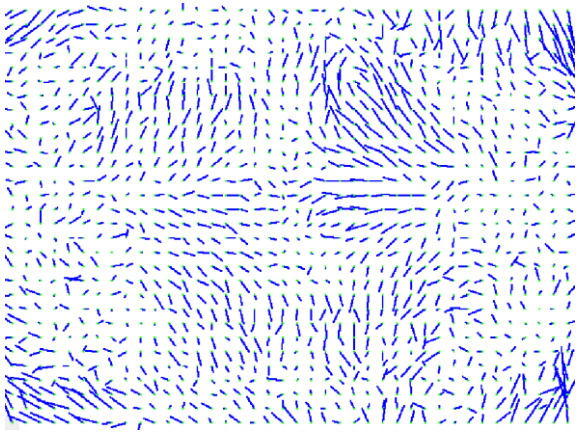
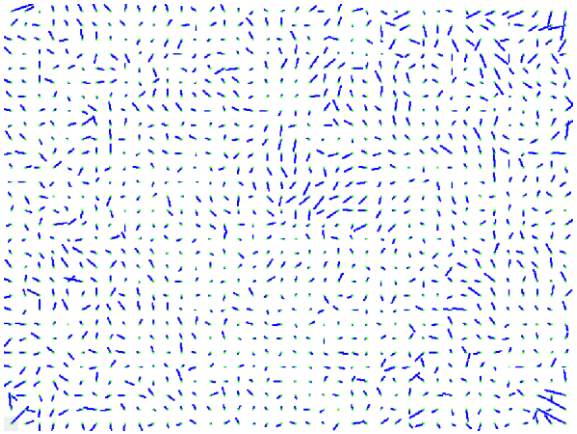
Reprojection Error

Average reprojection error of all automatic tie points

P2V+ at 8 m/s



Standard fisheye model



Rolling shutter model

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