Camera Image Acquisition: From Radiance to Detection of Objects

Christopher Dahlin Rodin

AGENDA

1. Geometry
   - Geometric models of camera projections
   - How is geometry applied in real world scenarios?
2. The Imaging Sensor
   - Overview, and detailed look on the parameters
3. Object Detection: SNR and Algorithms
   - Detection of objects at the sea surface

GEOMETRY | Geometric Models

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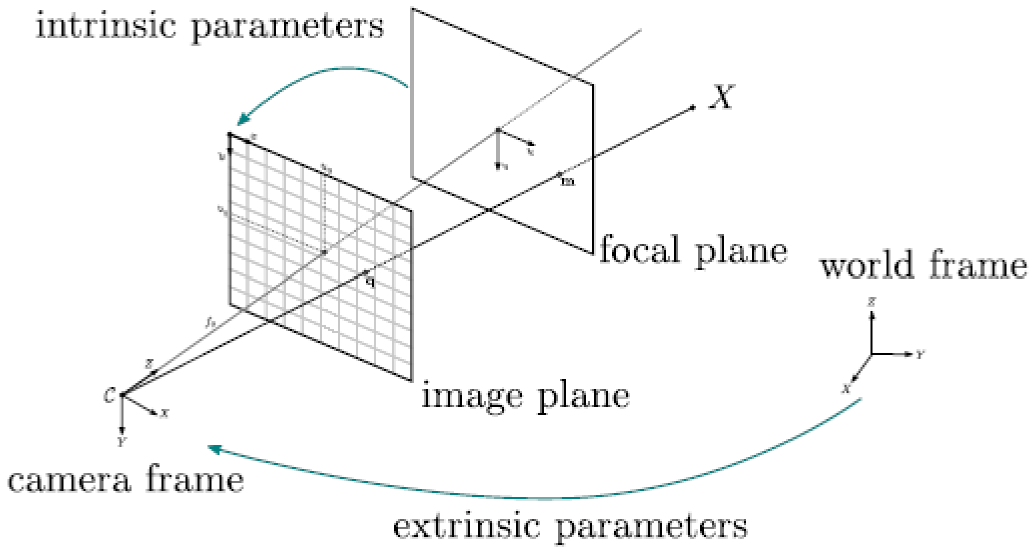
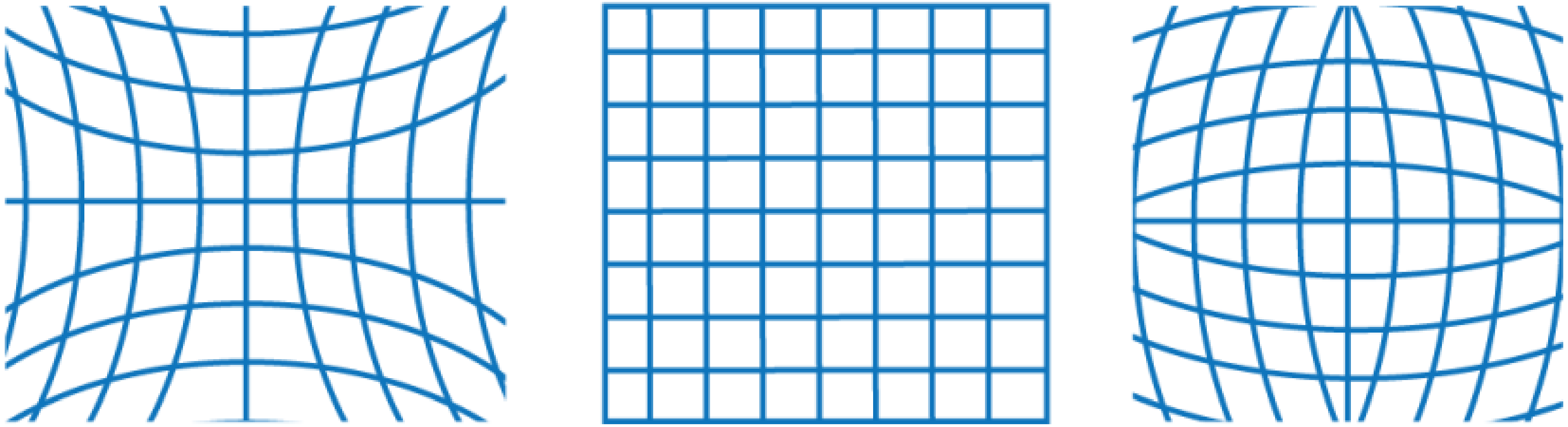
Pinhole camera model: projects a point in the world onto the image plane



GEOMETRY | Geometric Models

Lens distortion: deviations from a rectilinear projection



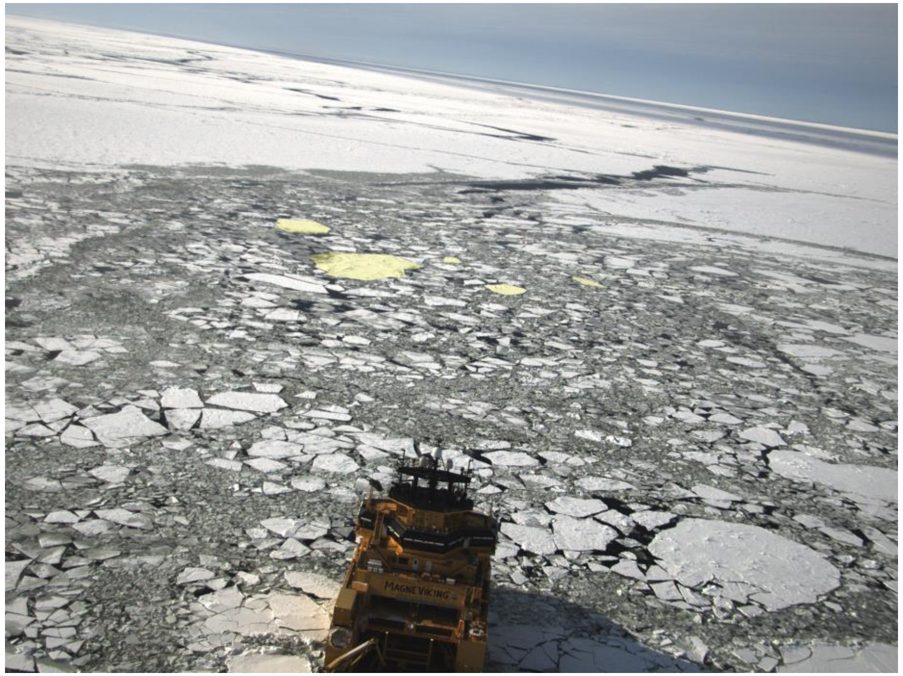
negative radial distortion "pincushion" | no distortion | positive radial distortion "barrel"

GEOMETRY | Size Estimation of Ice Floes

Real world application 1: Size Estimation of Ice Floes

GEOMETRY | Size Estimation of Ice Floes

- Problem: you want to be able to estimate the size of ice floes far away. How far can the camera do this accurately?



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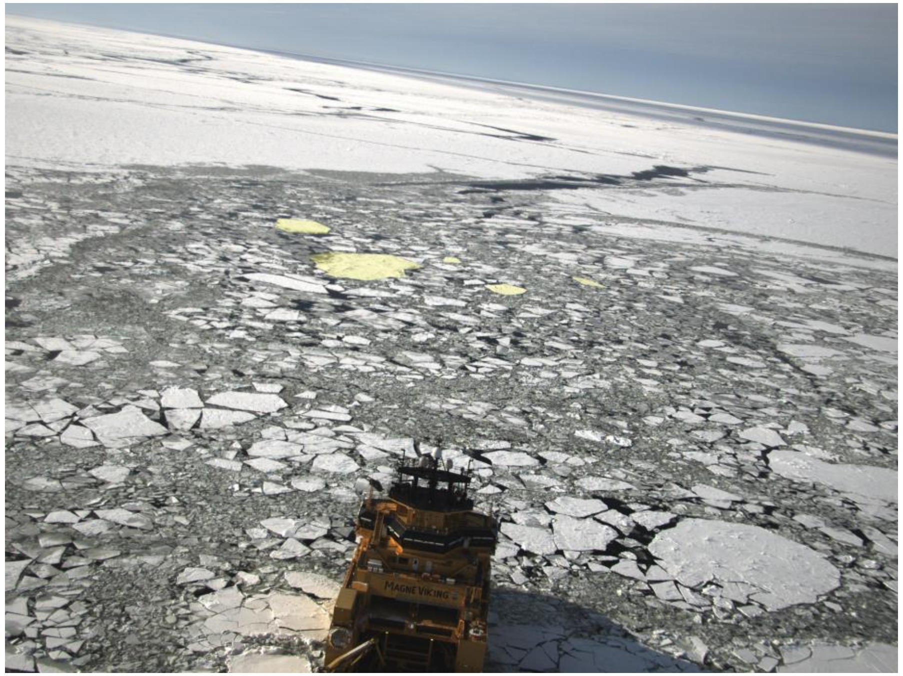
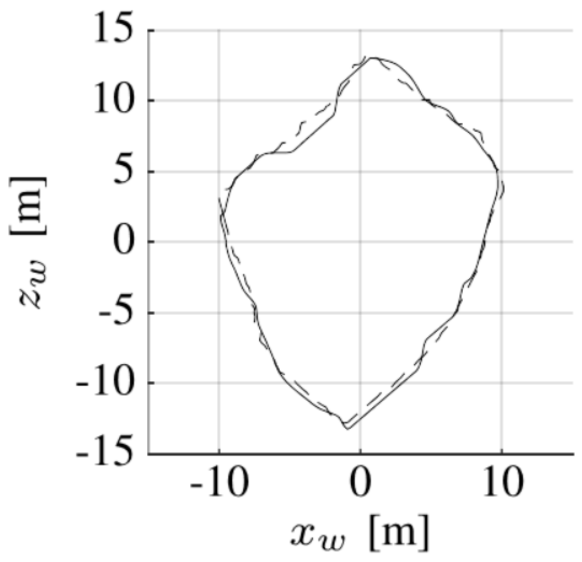
- Experimental data from SKT 2017



GEOMETRY | Size Estimation of Ice Floes

- As long as the ground resolution is enough to separate the objects, size estimation accuracy holds at highly slant angles



GEOMETRY | Size Estimation of Ice Floes

C. Dahlin Rodin, T.A. Johansen, *Accuracy of Sea Ice Floe Size Observation from an Aerial Camera at Slant Angles, RED-UAS 2017*

GEOMETRY | Camera Attitude Estimation

Real world application 2: Camera Attitude Estimation

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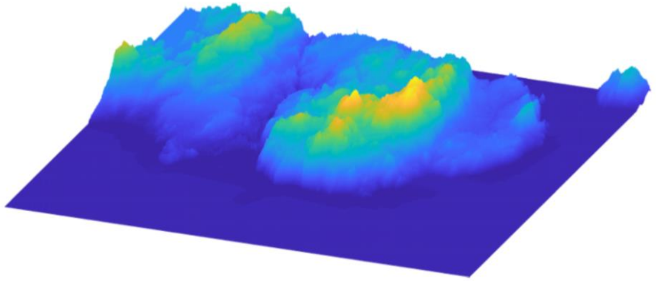

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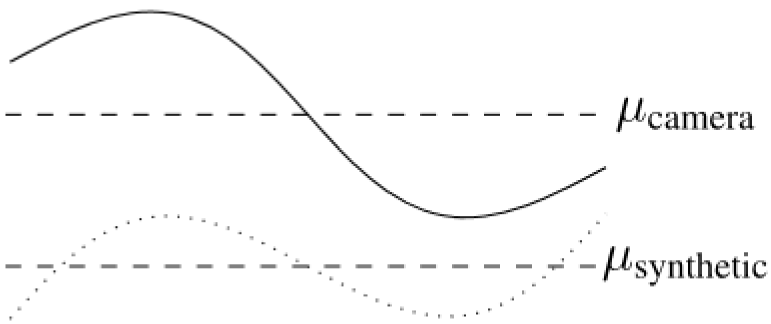
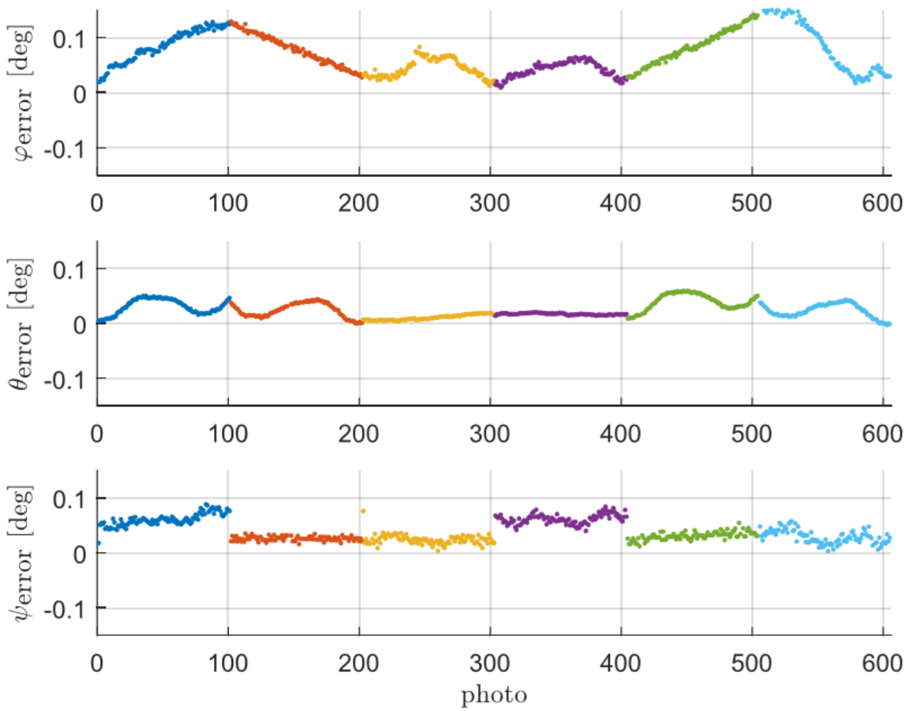


GEOMETRY | Camera Attitude Estimation

- Problem: small error in angle estimate gives a large error in georeferencing applications
- Solution: match rendered horizons with one in a camera image
- Methodology: use shape features of the horizons to quickly estimate roll and pitch, and iterative grid search for yaw

GEOMETRY | Camera Attitude Estimation



GEOMETRY | Camera Attitude Estimation

C. Dahlin Rodin, T.A. Johansen, A. Stahl, *Skyline Based Camera Attitude Estimation Using a Digital Surface Model*, AMC 2018

THE IMAGING SENSOR

”With every airborne camera, the aim is to achieve the best possible signal/noise ratio (SNR) in order to be able, at all processing stages, to work with data that are as close as possible to the information they contain.”

Rainer Sandau, Digital Airborne Camera: Introduction and Technology (2010)

THE IMAGING SENSOR | The Camera Equation

- Describes the conversion from radiance to pixel intensity

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Light source	Irradiance [W/m^2]
Sunlight	1000
Skylight	100
Overcast daylight	10
Moonlight	0,001
Starlight	0,0001

THE IMAGING SENSOR | The Camera Equation

- Describes the conversion from radiance to pixel intensity

$$I \propto L(\lambda) \cdot T_{optics}(\lambda)$$

Spectral transmittance of the optics: how much of the light passes through?

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$$I \propto L(\lambda) \cdot T_{optics}(\lambda) \cdot R(\lambda)$$

Relative illuminance factor: relative illuminance compared to the optical axis.

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- Describes the conversion from radiance to pixel intensity

$$I \propto L(\lambda) \cdot T_{optics}(\lambda) \cdot R(\lambda) \cdot f\#^{-2}$$

F-number: focal length / diameter of entrance aperture

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Pixel area: physical dimension of one picture element.

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$$I \propto L(\lambda) \cdot T_{optics}(\lambda) \cdot R(\lambda) \cdot f\#^{-2} \cdot A_{px} \cdot t_{exp}$$

Integration time: time during which the image sensor is exposed to light.

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- Project: detection and classification of objects at the sea surface
- *Adaptive background mixture models for real-time tracking*