Camouflage evaluation by bio-inspired local conspicuity quantification

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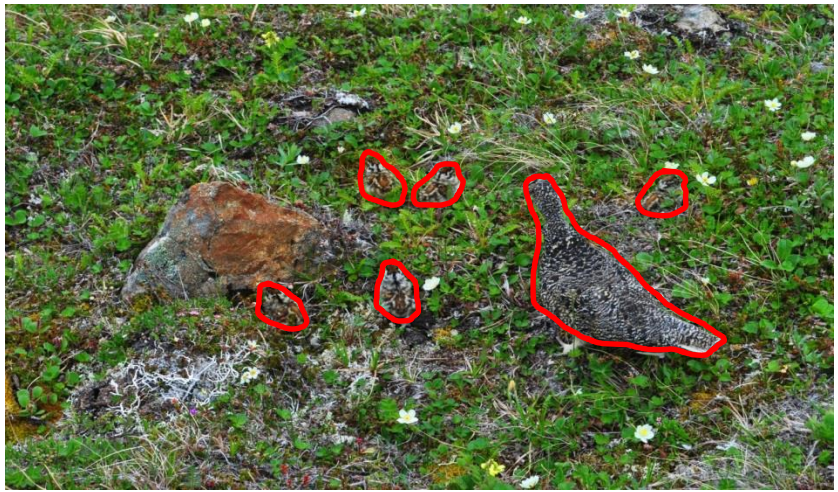
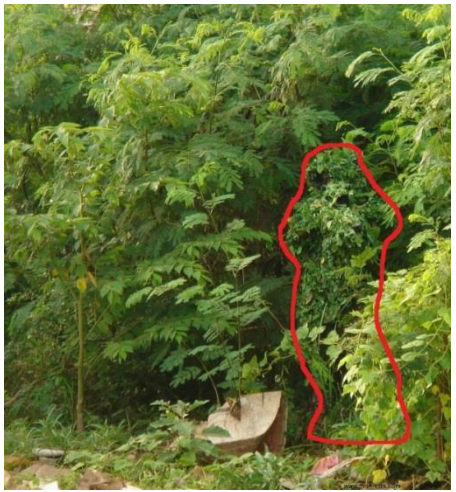
Camouflage and visual attention

- Gain the attention of individuals - passing information
- Avoid the attention of enemies





Camouflage Assessment

Assessment of Local Conspicuity

- Numeric analysis (ALOPEX) **AL**gorithms for C**o**nspicuity **P**arameter **Ex**traction

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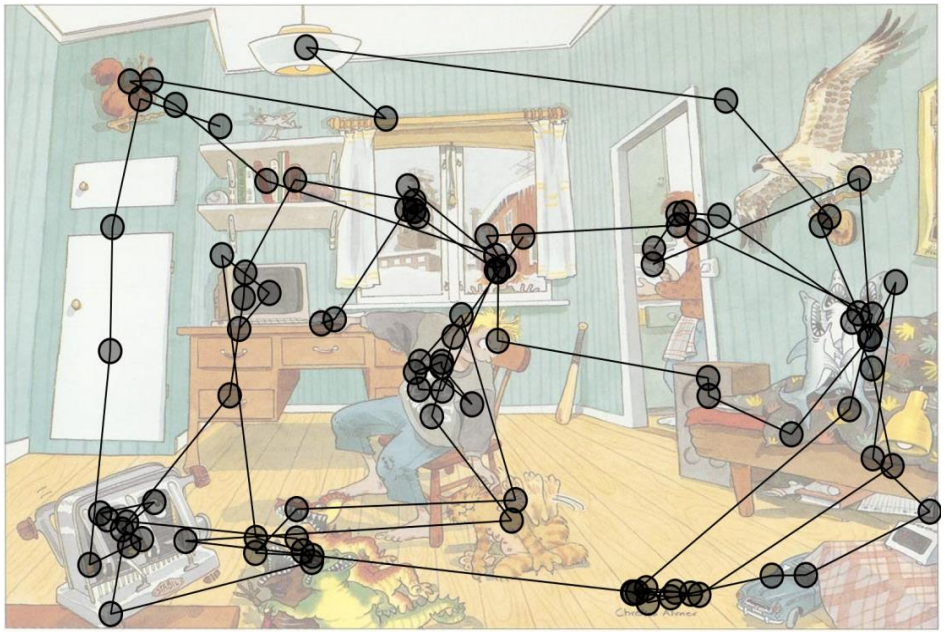
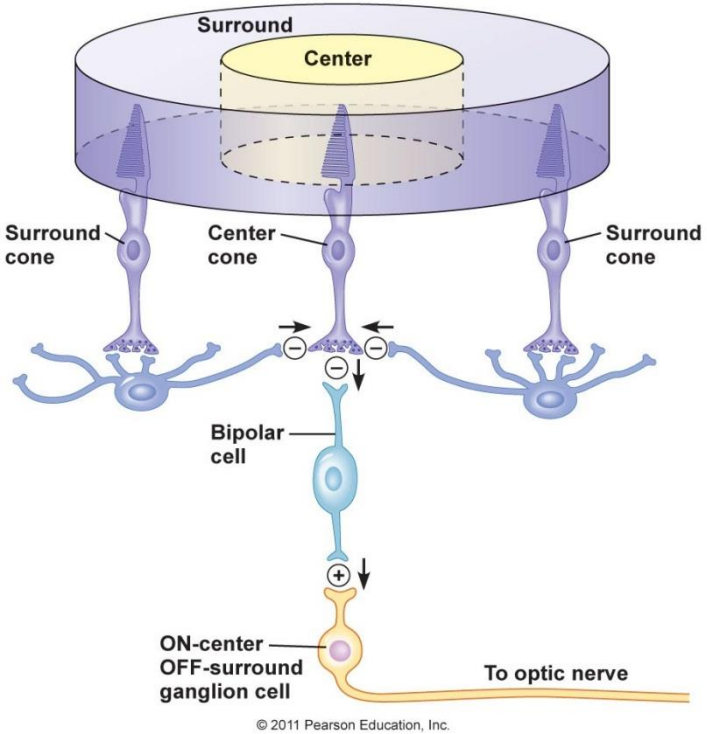
Eye Movements and Receptive Fields

- Saccadic Eye movments to regions of visual attraction
- Anomalies in the peripheral vision
- Search tasks and motivation can change the movement pattern, but not the saccadic fixation pattern



Eye Movements and Receptive Fields

- Receptive Fields for center surround comparison of image parameters
- Local Anomalies excite the receptive fields and lead to target selection for next eye fixation point
- Model this mechanism in order to quantify regions in the image for the fixation likeliness
- The less, the better camouflaged



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Eye Movements and Receptive Fields

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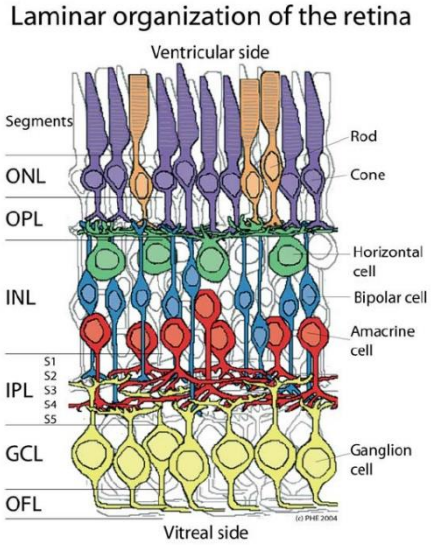

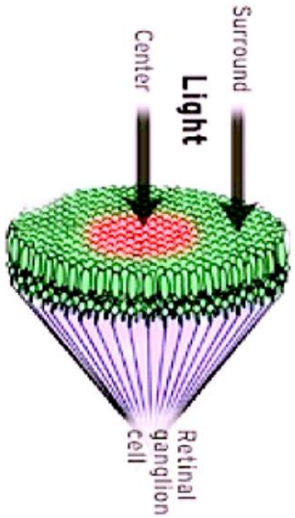

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ALOPEX Workflow

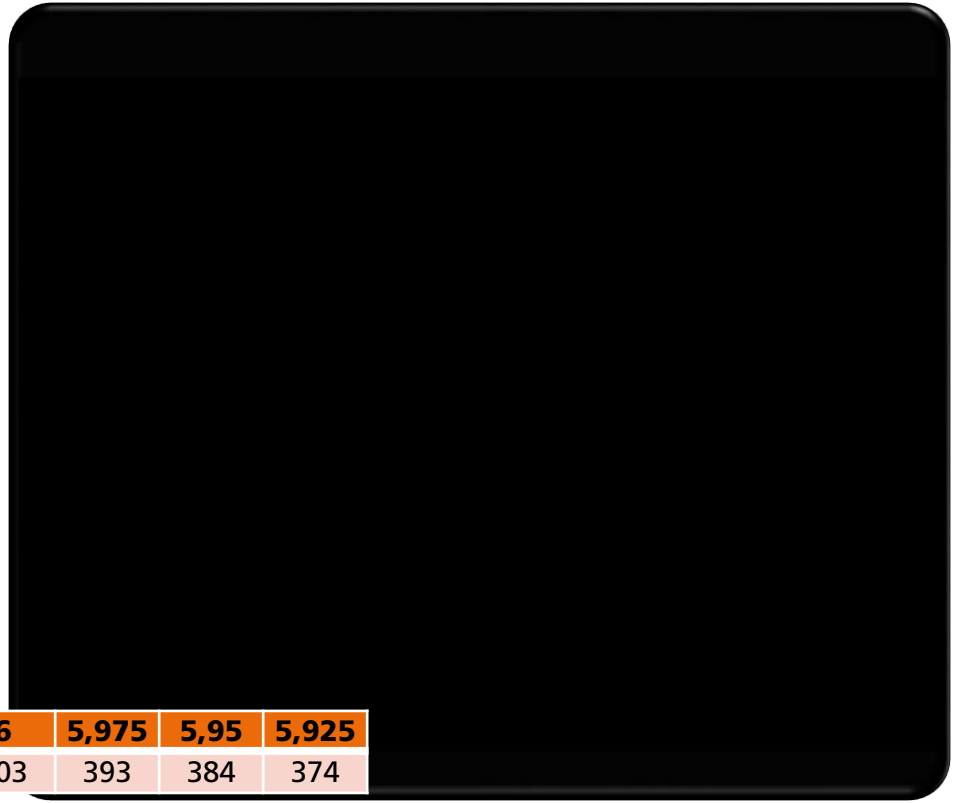
Anflugsequenz (optional)

Videoverarbeitung

Einzelbilder, ROIs, Homographien

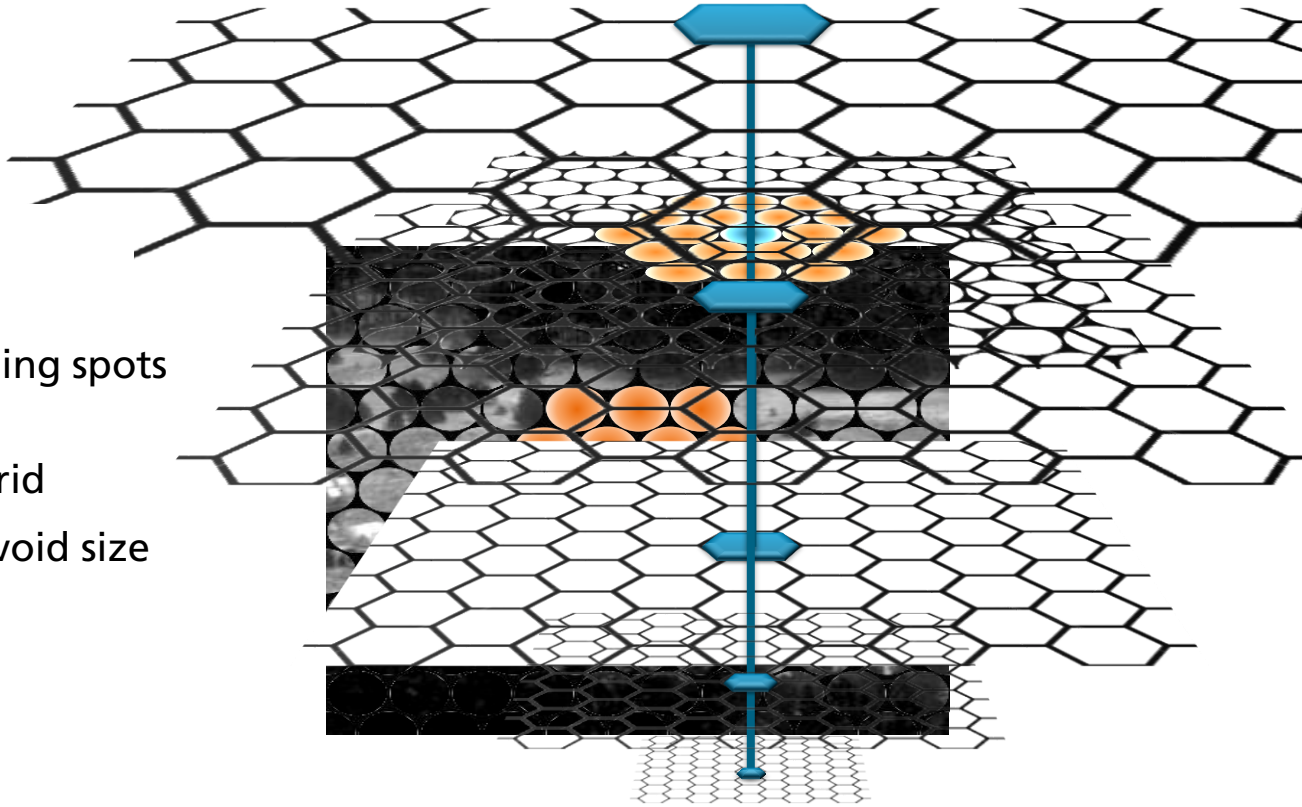
Homography and Keyframes

- Homography – Estimating the scenery as a plane and calculate its 3D movement in space
- Can be used to predict the movement of stationary objects (even if they are not in the image)
  - Automatically move the ROI
  - Image stabilization
- Logarithmic Distance for Keyframe selection



log(m)	9	8,975	8,95	8,925	8,9	[...]	6	5,975	5,95	5,925
m	8103	7903	7708	7518	7332		403	393	384	374

Conspicuity Evaluation



Sampling

- Circular weighted sampling spots were necessary
- Favorable: Hexagonal Grid
- Multi-scale analysis to avoid size effects

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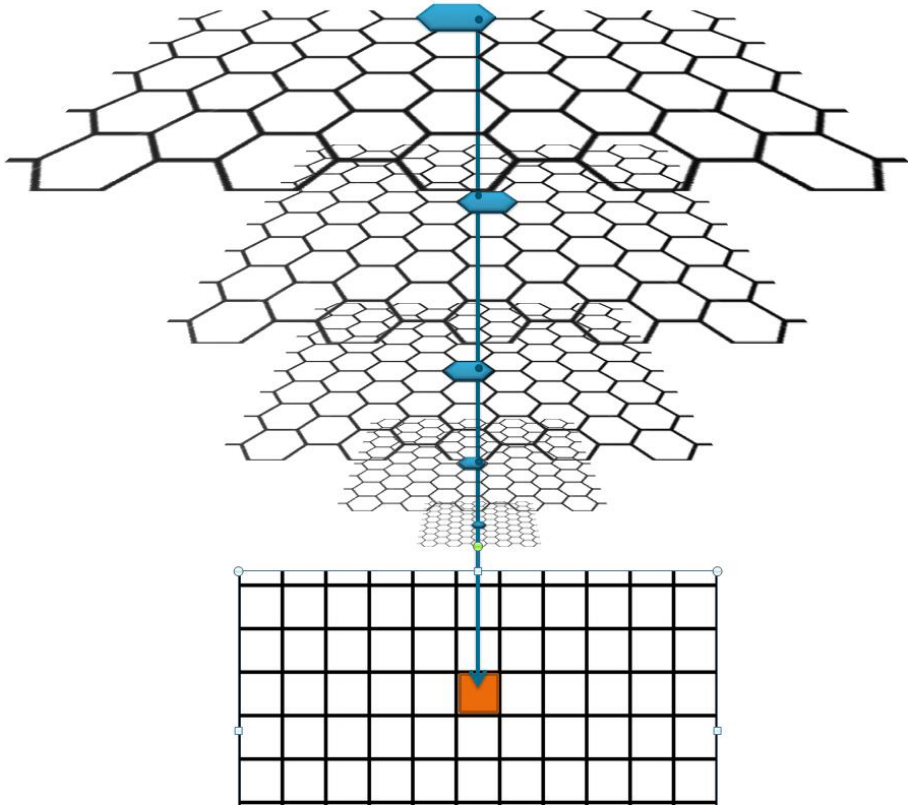

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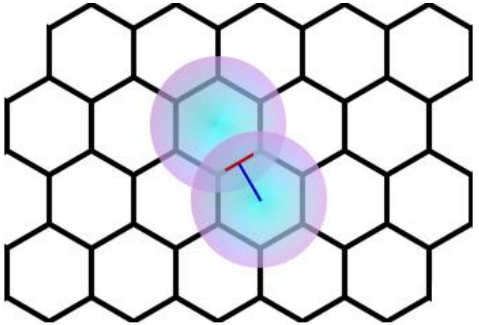

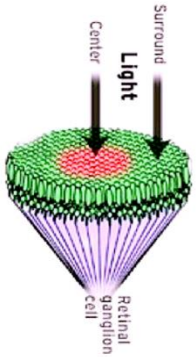

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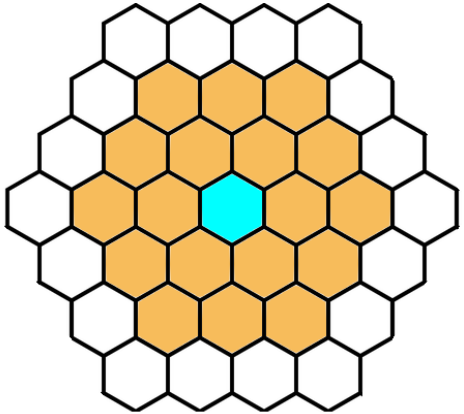

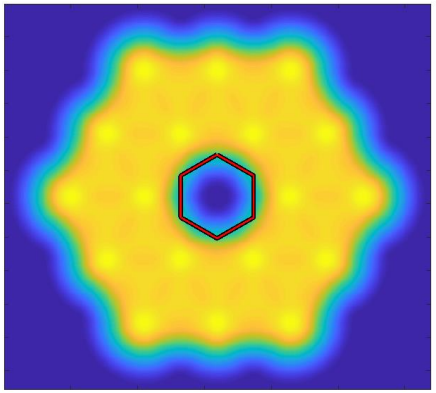

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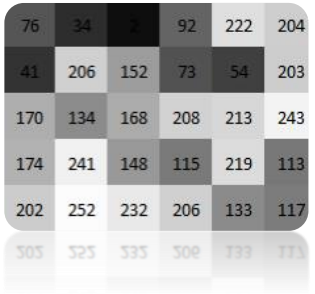
Image statistics / local parameters



- Needed: suitable set of image parameters, biologically plausible for human obsververs
- Model for center surround comparison to obtain conspicuity maps

Linear / GLCM

- Color difference *(CIELAB)*
- Mean luminance
- Root mean square contrast
- Angular second moment
- correlation
- energy
- homogenity
- entropy

Fourier

- Power law exponent α
- Noise deviation
- Repeating patterns
- Orientation inequality factor
- Rectangularity

Radon

- Linear elements
- Creasiness
- Corrugation

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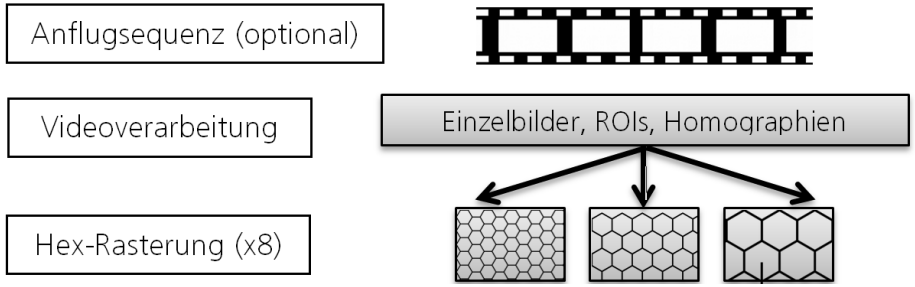
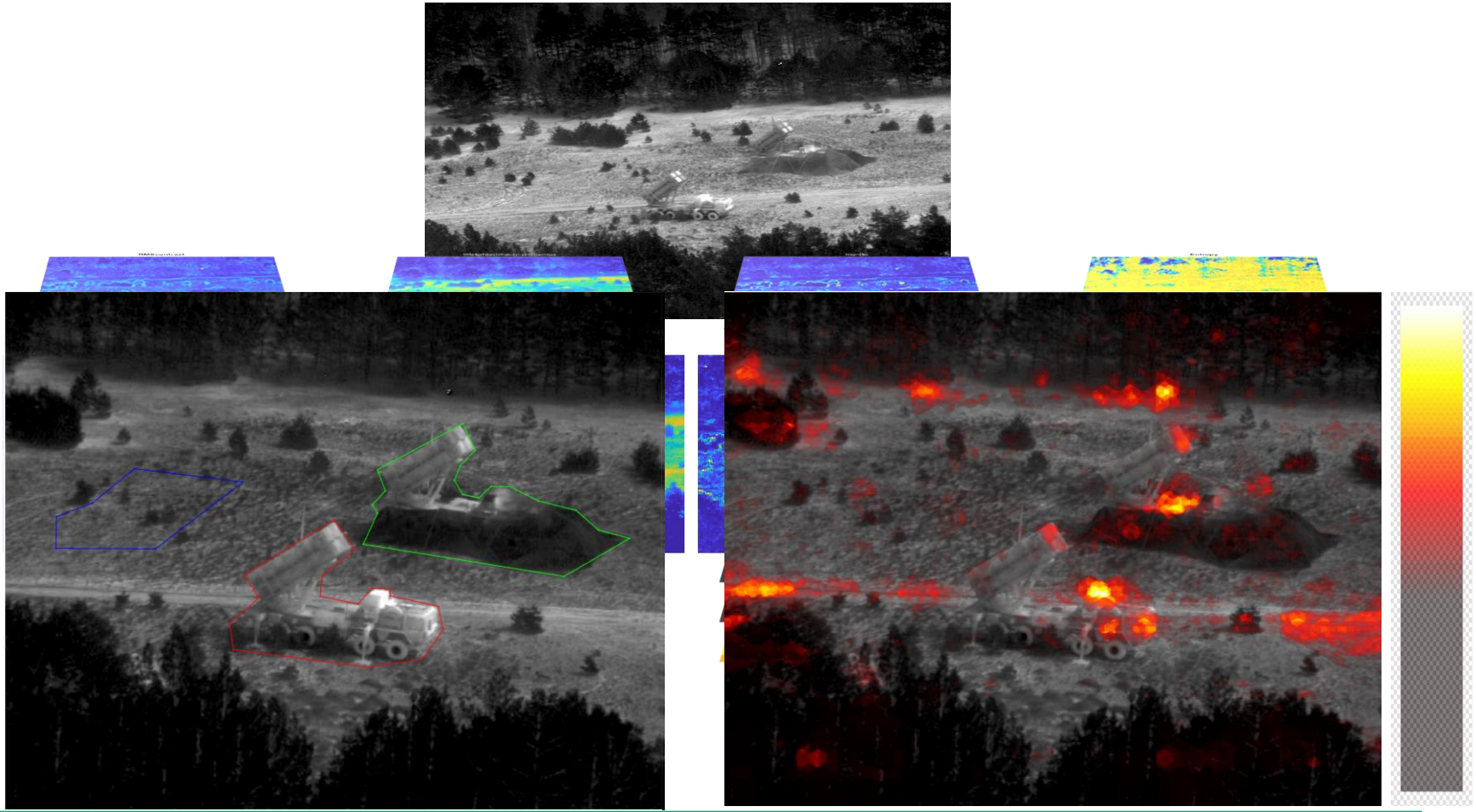
ALOPEX Workflow





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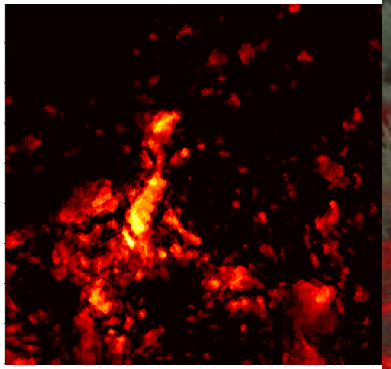
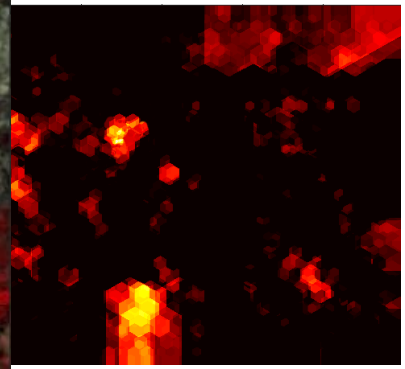
Results

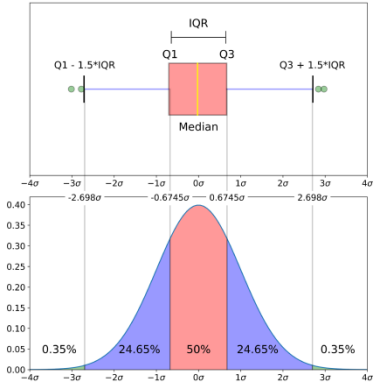
Color Difference

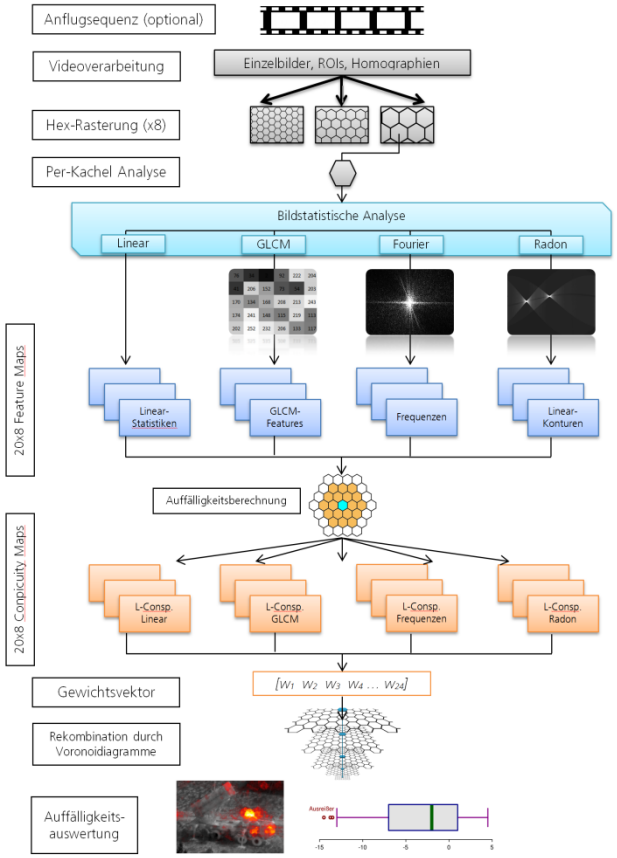


don (Corrugation)



ALOPEX Workflow





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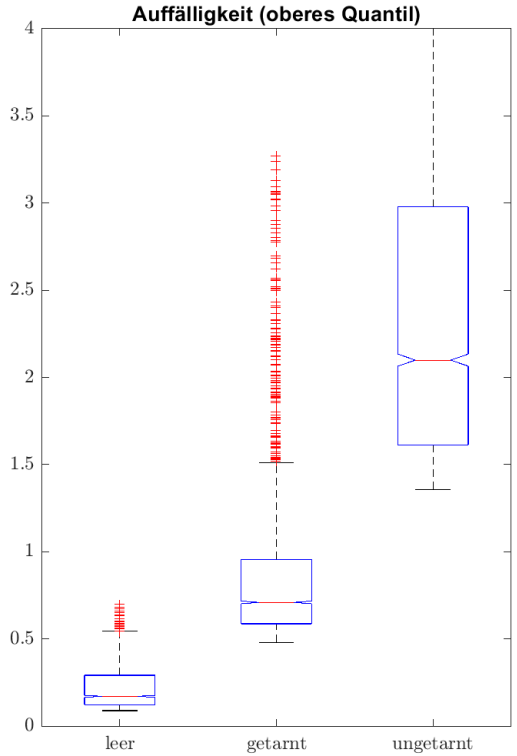
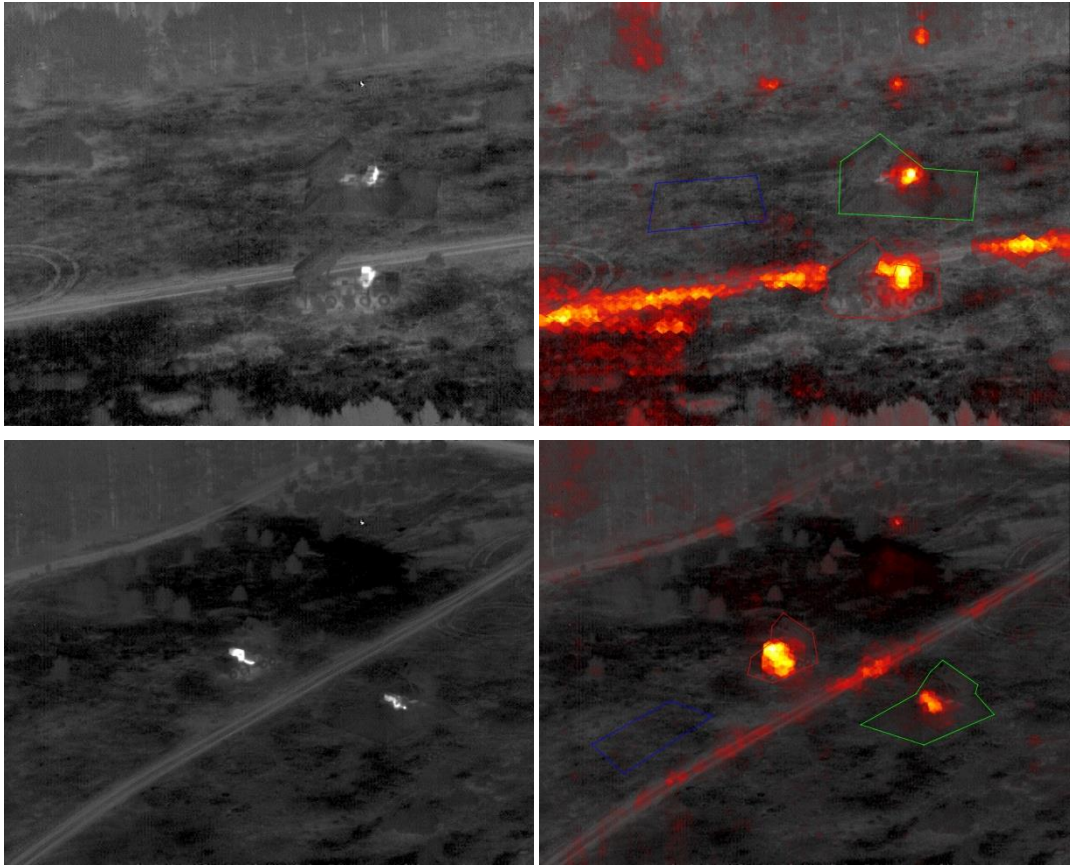
Assessment





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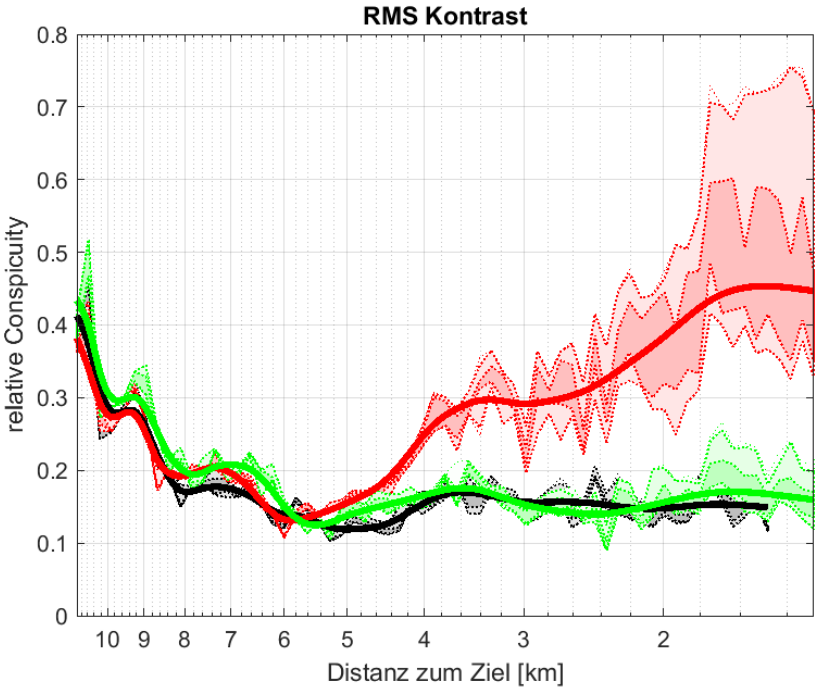
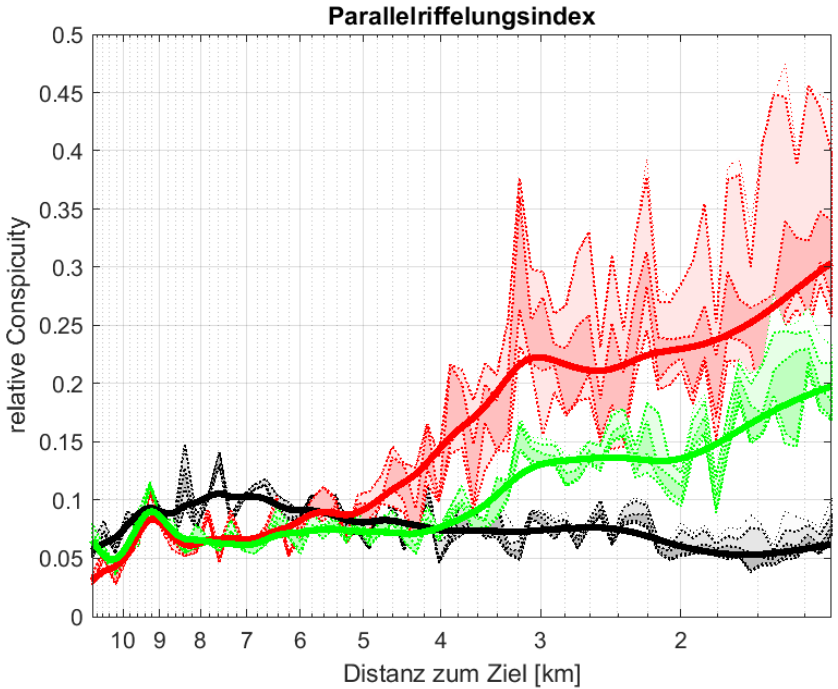
Camouflage effectiveness in approach flights





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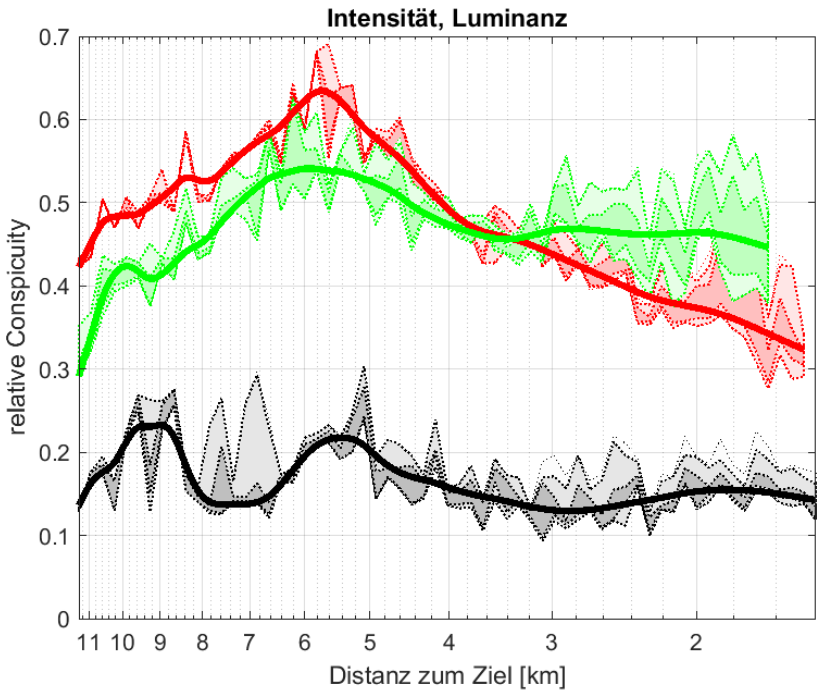

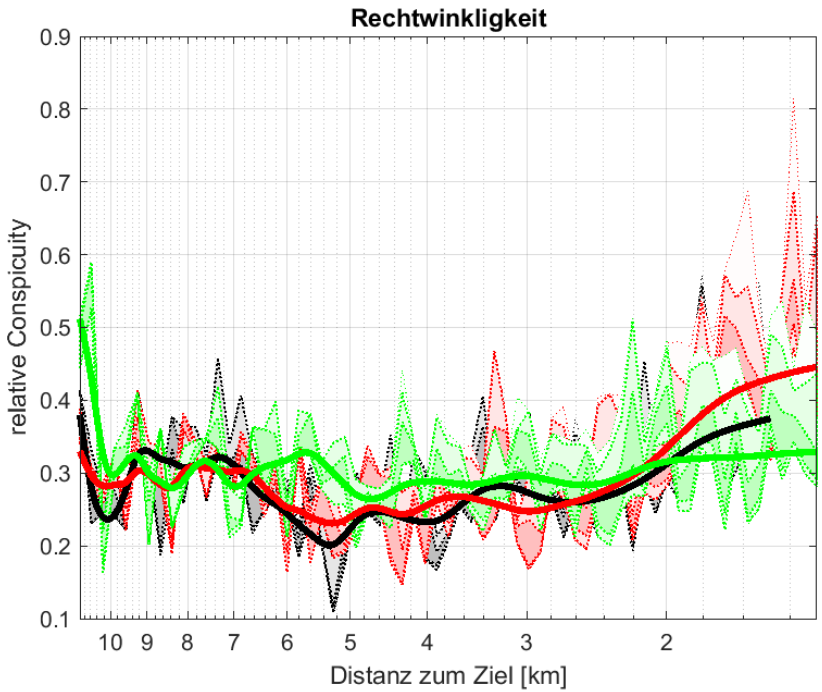

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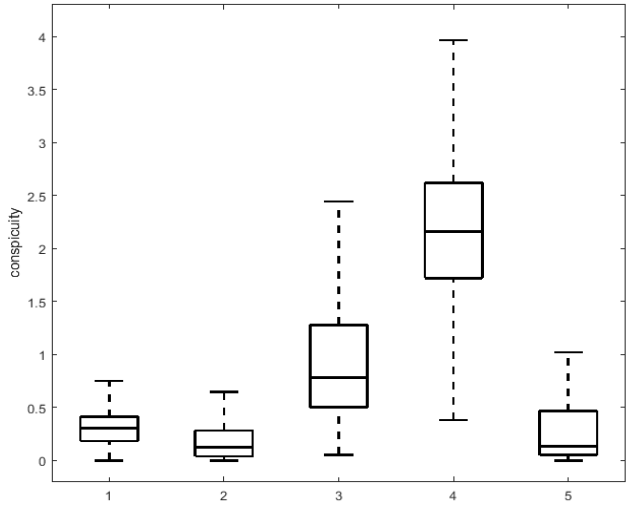
Evaluation of Camouflage



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Summary

- Camouflage is important to enhance military effectiveness by increasing the survivability of the unit
- Quantification of conspicuousness to determine effectiveness of camouflage in advance and to improve it prior to the mission.
- Not limited to Bandwidth
- Can be tuned to different tasks, by adapting the weighting of the different conpicuity maps

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Thank you for your interest and attention

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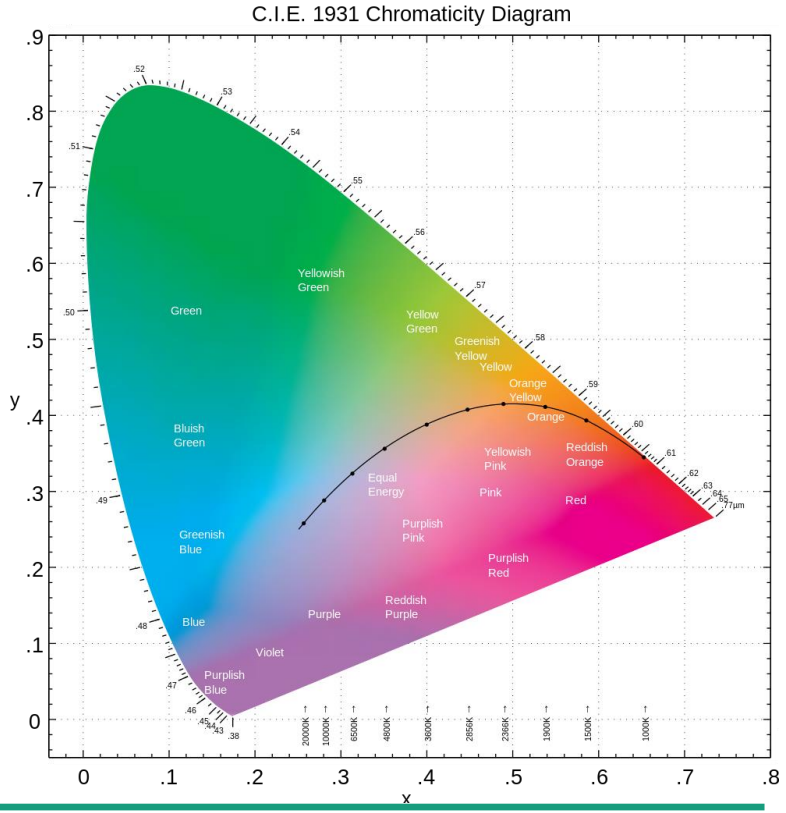
APPENDIX

Image statistics / local parameters

- Color Difference
- CIELAB Colorspace
  - Weighted to represent human volor reception
  - Spatial distance of colors represent the precieved color difference



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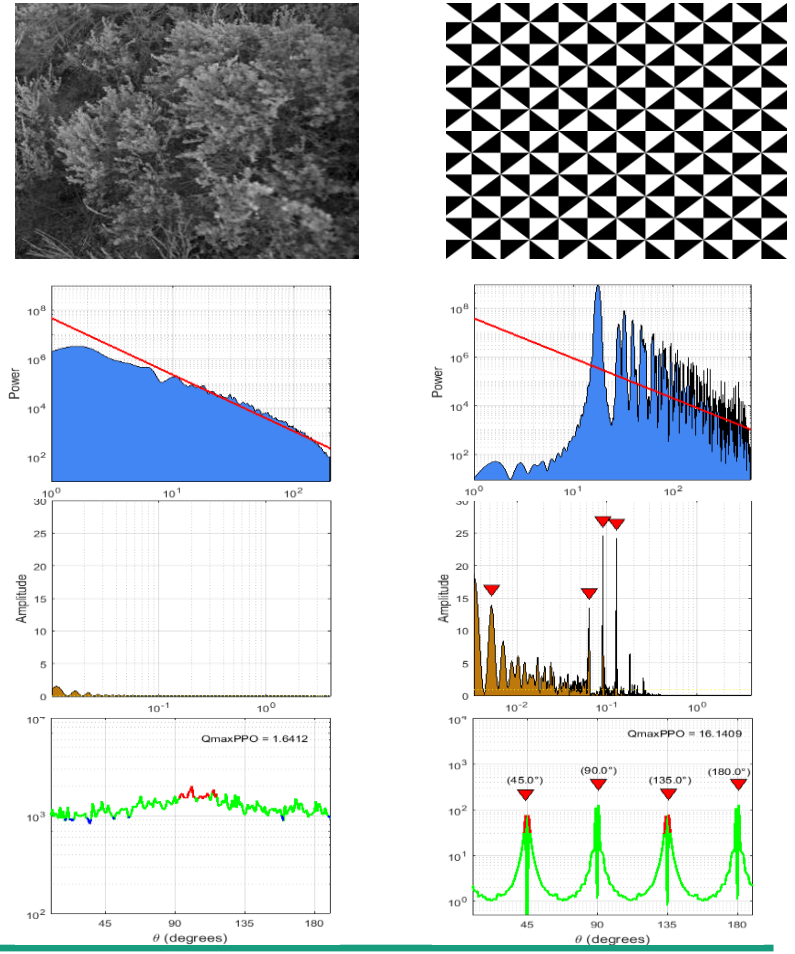
Fourier transform

$$F(\omega) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} f(t) e^{-i\omega t} dt$$

- Spatial frequency analysis
- ***Frequency dependent power spectrum***
  - frequency ratio and noise deviation
- ***Cepstrum***
  - high amplitude peaks for repetitive texture elements
- ***Orientation dependent power spectrum***
  - Orientation of spatial frequencies



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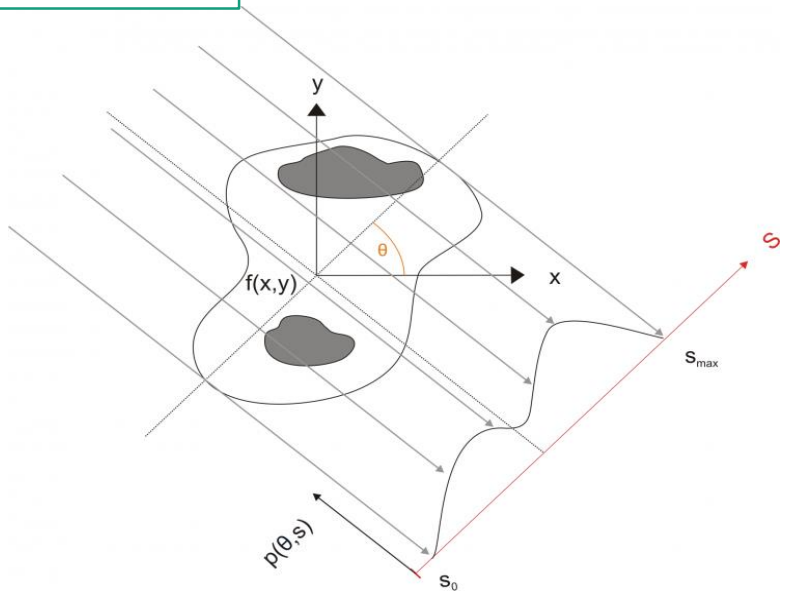
Radon Transform

$$R(r,\theta)[f(x,y)] = \iint_{-\infty}^{\infty} f(x,y)\delta(x\cos\theta + y\sin\theta - r)dxdy$$

- Line integration of the function $f(x,y)$
- Known from Tomography
- Can be used to detect linear elements
- Derivative of r can be used for localizing linear elements

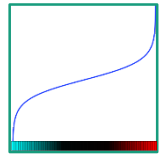


Fraunhofer IOSB

Radon Transform

Rf

δ

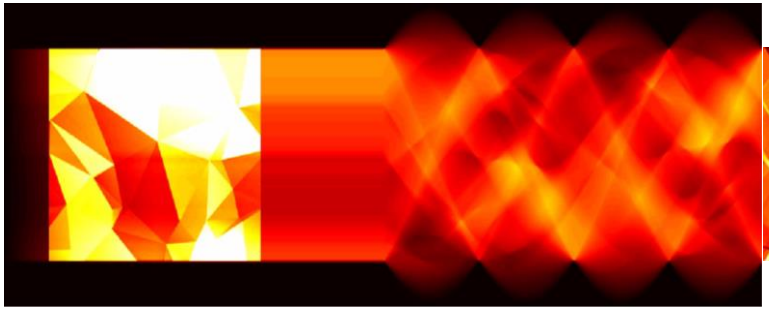


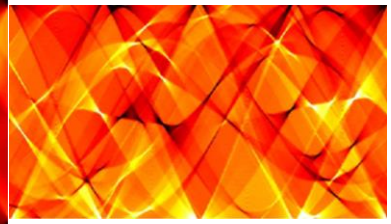
Σ

Radon Transform

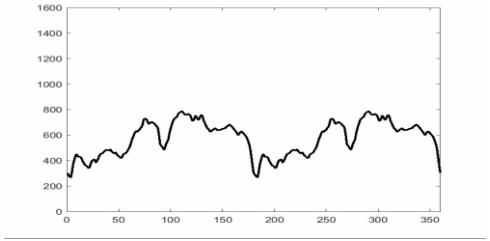
Rf

δ





Σ



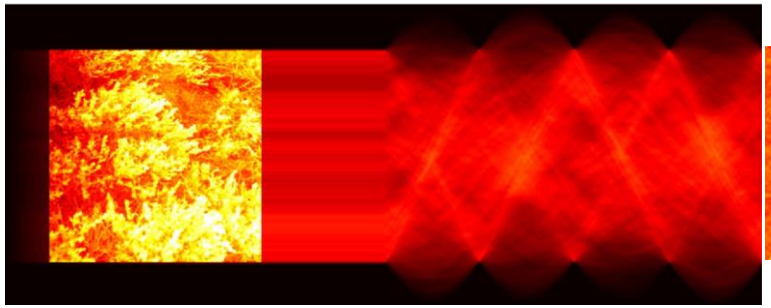
Fraunhofer IOSB

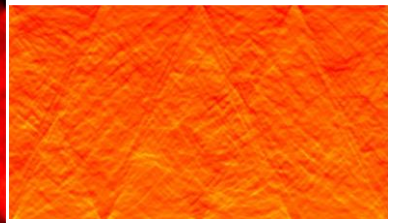
Radon Transform

Hough Transform

Rf

δ





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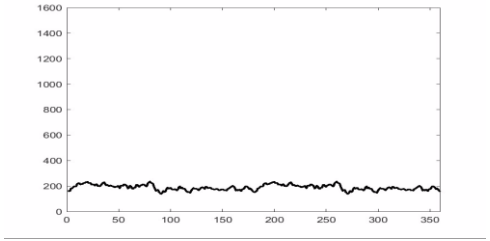

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Radon Transform

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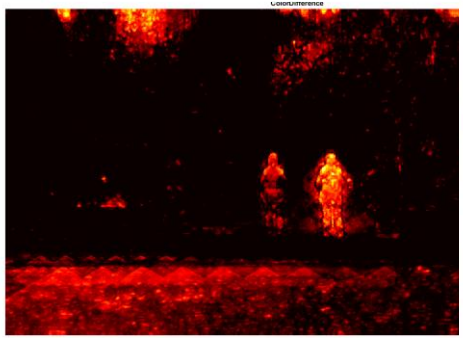
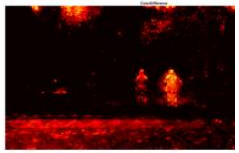
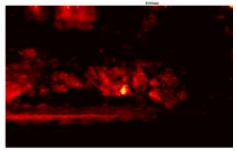
- Derivative of r can be used for localizing linear elements
- If the sum of the derivative shows peaks for specific orientations, this hints towards a pronounced parallel corrugation
- Is the mean value of the summed derivatives over all orientation is high, it hints to a high undirected corrugation (creasiness)

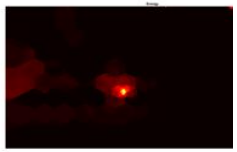
Results

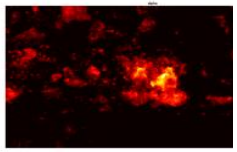
Color Difference

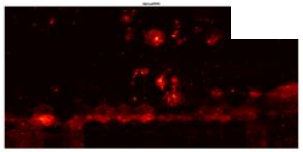


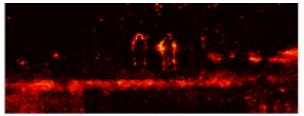


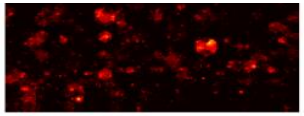












Results