DATA FROM SKY

ultimate aerial analysis

Data From Sky

Satellites, 50 cm/pixel

Autonomous drones, 20 cm/pixel

Fixed cameras – tall buildings

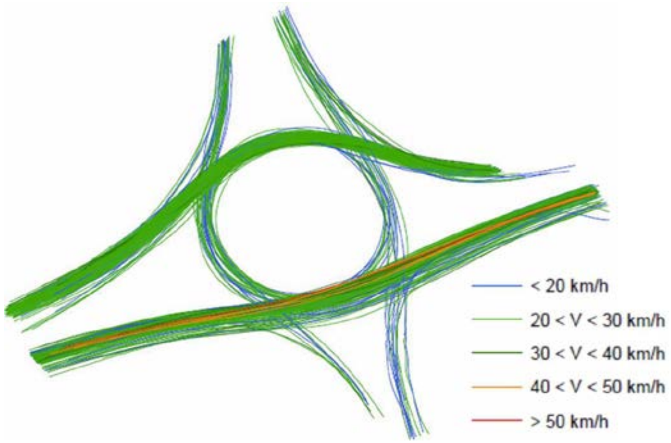
Applications in traffic

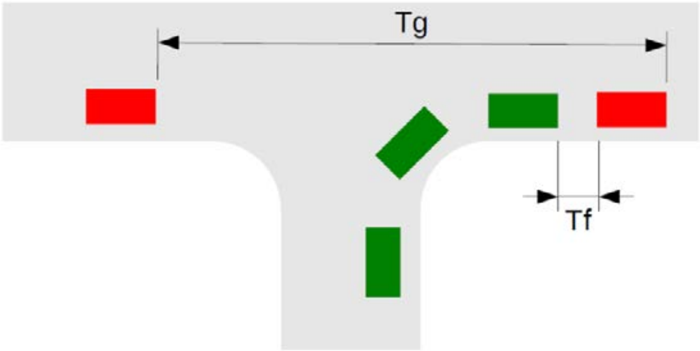
Monitoring: traffic intensities

Capacity: analysis of traffic flow

Safety: audit of critical regions, trajectory interactions, conflicts

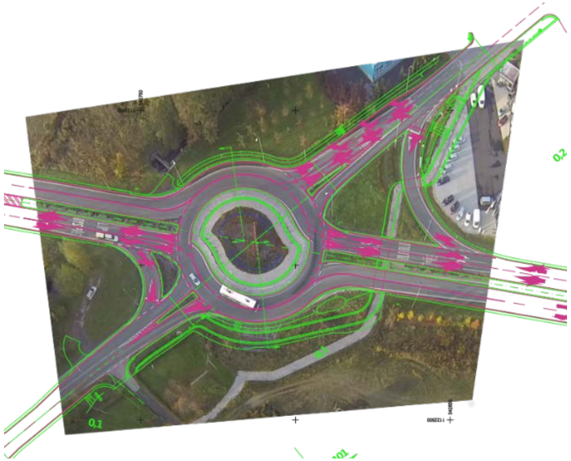
Meta-Analysis: gap-time and time to follow, emission of solids a NOx



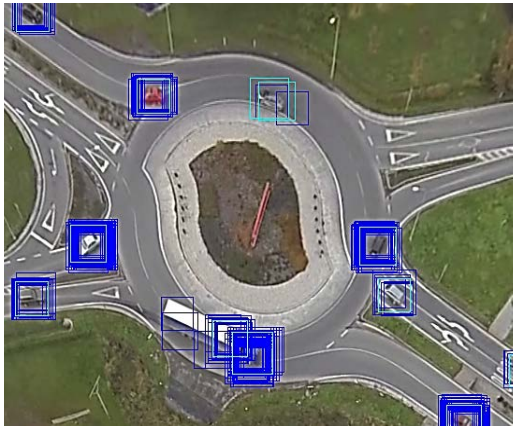


How it works

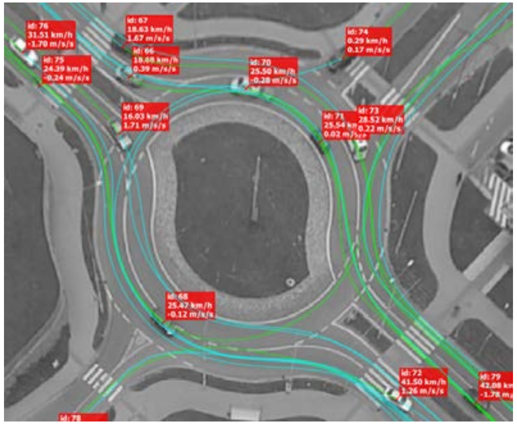
Geo-registration



Detection



Tracking

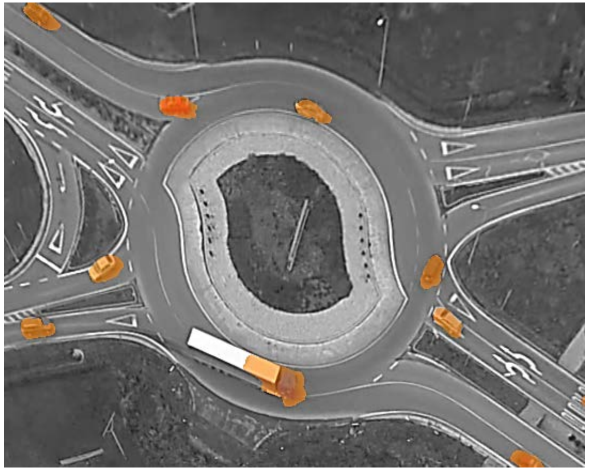


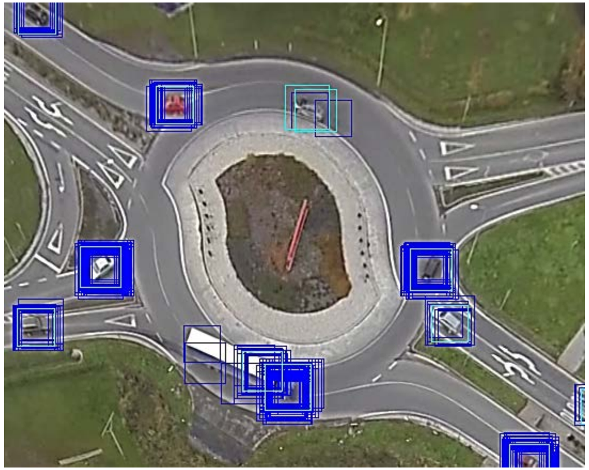
Previous Approach (2014)

Cascade Classifier - **AdaBoost**

- 80 k training samples
- Prefiltration of detection candidates (by road surface and movement cues)

Accuracy: ≈**80 %** on validation data





We have data… Let’s use them!

Annotated high-resolution video data

- **280+ hours** of total footage length
- **500 000+** tracked vehicles:
- **50 000+ km** traveled by vehicles

Prospective HUGE training/validation set

Deep Neural Networks

Our tools

Caffe

NVIDIA DIGITS

Dedicated Learning Server with nVidia GeForce **GTX 1080**

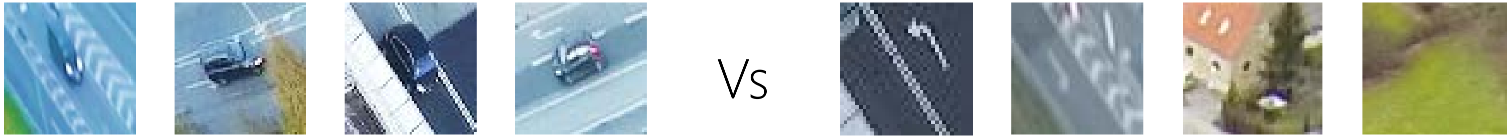
- 8 GB GDDR5X RAM
- 2560 CUDA cores
- 9 TFLOPS

Different Data

VS

Classification – proof of concept

Can DNN work with such tiny objects?



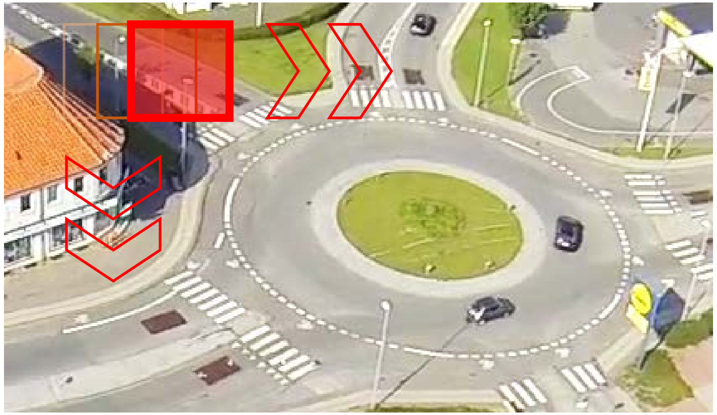
Tried: ConvNet, GoogLeNet, Custom Architecture

Problems: Training from scratch, too aggressive data reduction, low abstraction.

Final Architecture: **ResNet-50**

- residual, 50 layers
- 7.4 M training samples
- **Accuracy: > 98 %** on validation data

Sliding Window



Shortest path from Classifier to Detector.

- WAY too slow!
  - 400 k+ detection candidates per frame (without constraints)
  - few minutes per FullHD frame

- Prefiltration of detection candidates (by road surface and movement cues)
  - Noticeable speed-up (in order of 100x) ☺
  - Introduces unwanted localization bias ☹

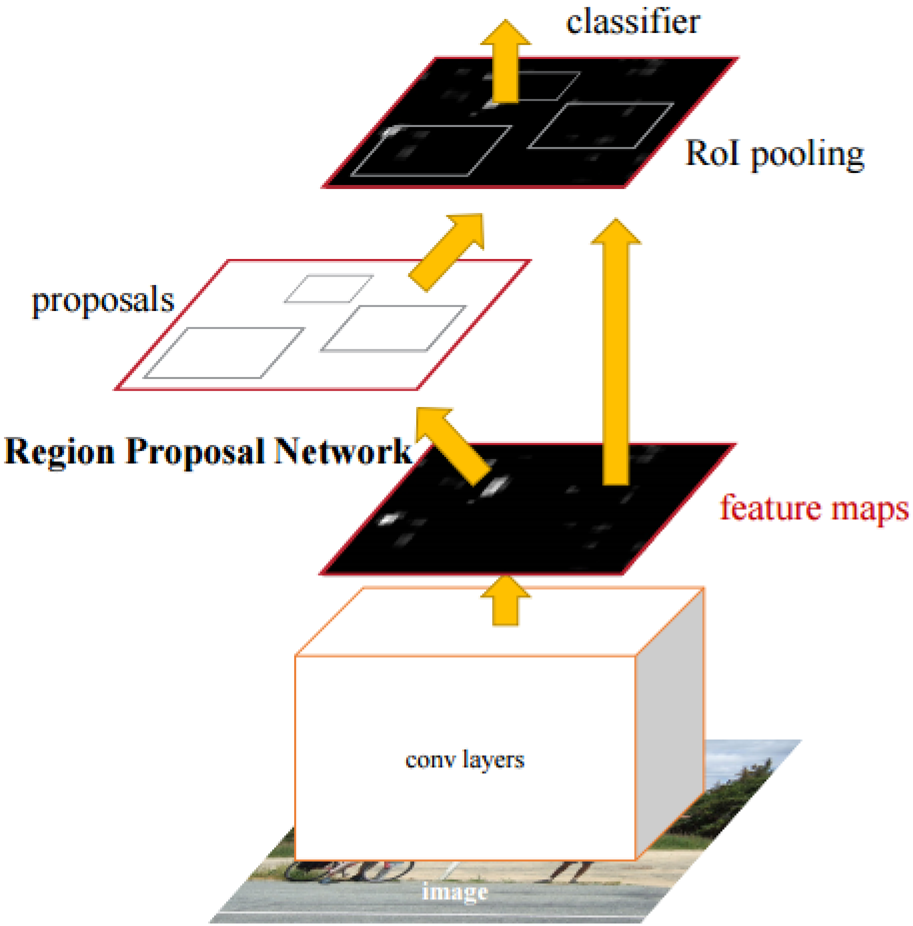
Faster R-CNN

Complex End-To-End Solution.

- Human Attention
- Input = FullHD image
- Output = List of Detections

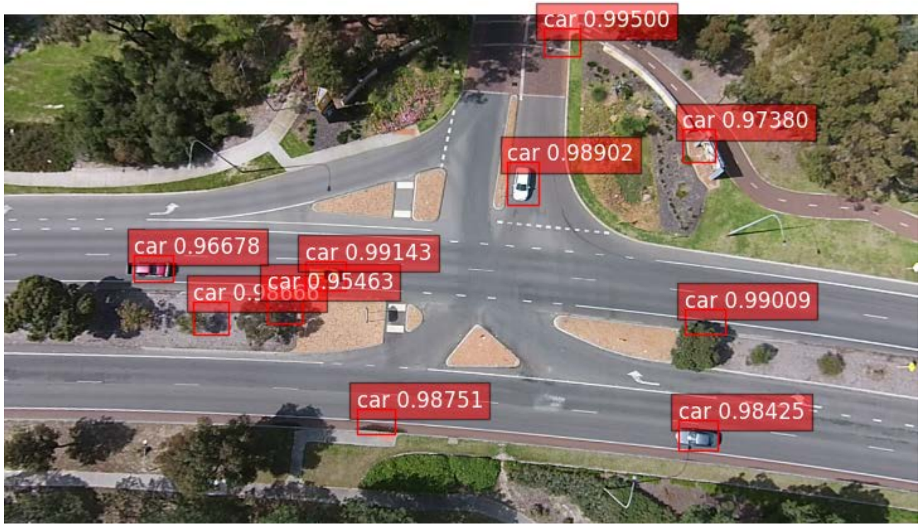
Modifications:

- VGG-CNN1024
- Custom RPN
- Wrapper for our datasets



Output

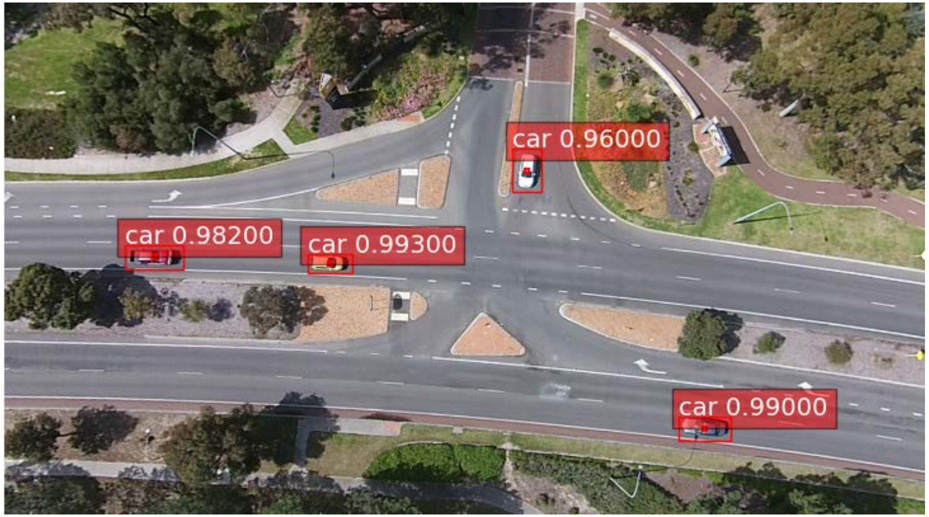
ResNet-50 + Sliding Window



mAP = 0.647

Detection Time: 77 s/frame

Faster R-CNN

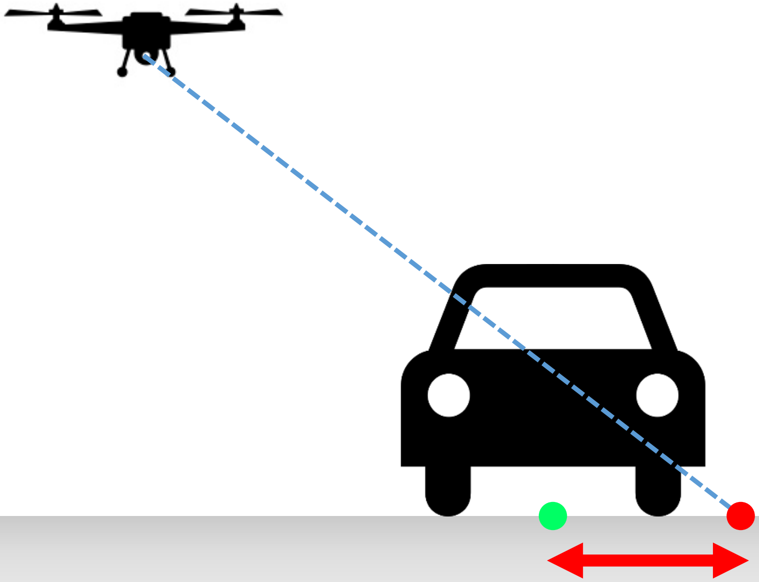


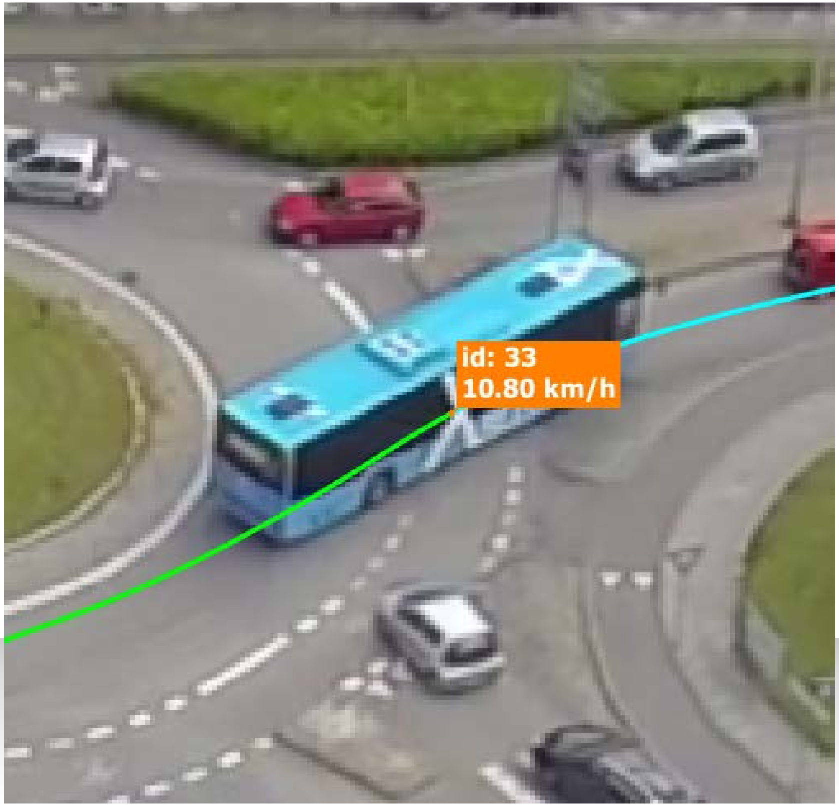
mAP = **0.986**

Detection Time: **0.110 s/frame**

Localisation Offset

Oblique capture of the scene

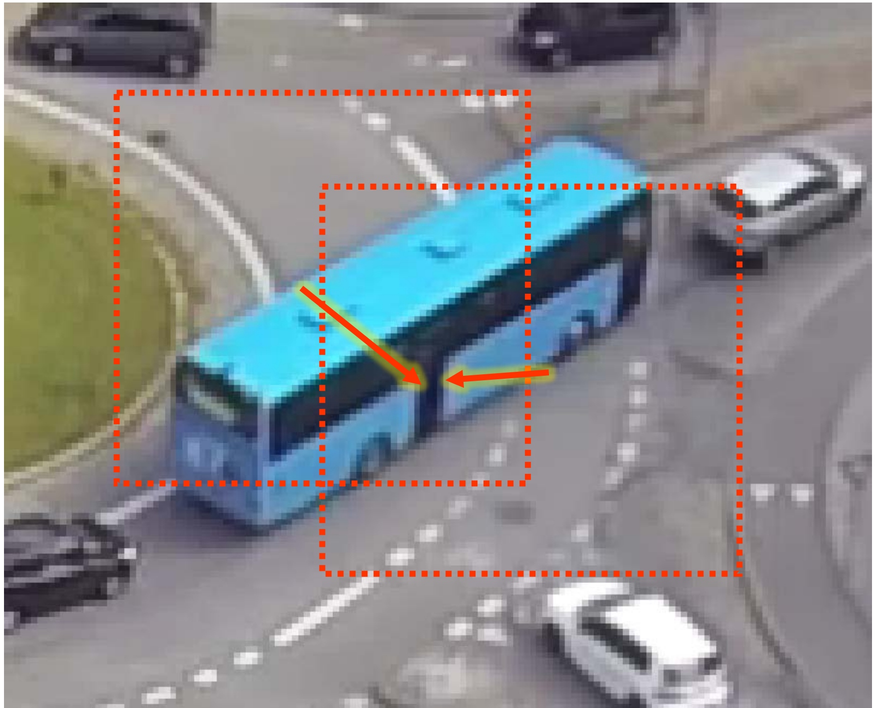




Accurate Localisation = Spatial Regressor

Idea from J. Prokaj: *Persistent Tracking for Wide Area Aerial Surveillance* (CVPR2014)

Principle: “Teach network to show where the vehicle is in the sample.”



(X, Y) = displacement to vehicle position

W = certainty of estimation

- Consensus from nearby samples
- Robust to bias from candidate filtration
- Can be iteratively applied

Be Careful When Diving Into DNN!

- Good Classifier ≠ Good Detector
- Find balance between abstraction and data reduction
- Tiny input for tiny data
- Even small DNN do really need huge memory
- We ran out of file-system **inodes** due to huge amount of training data.
  - Change configuration of Ext4, or use XFS, ReiserFS
- Moving datasets with millions of samples is time-consuming
  - Archives / virtual hard drives

Looking forward to tell you more…

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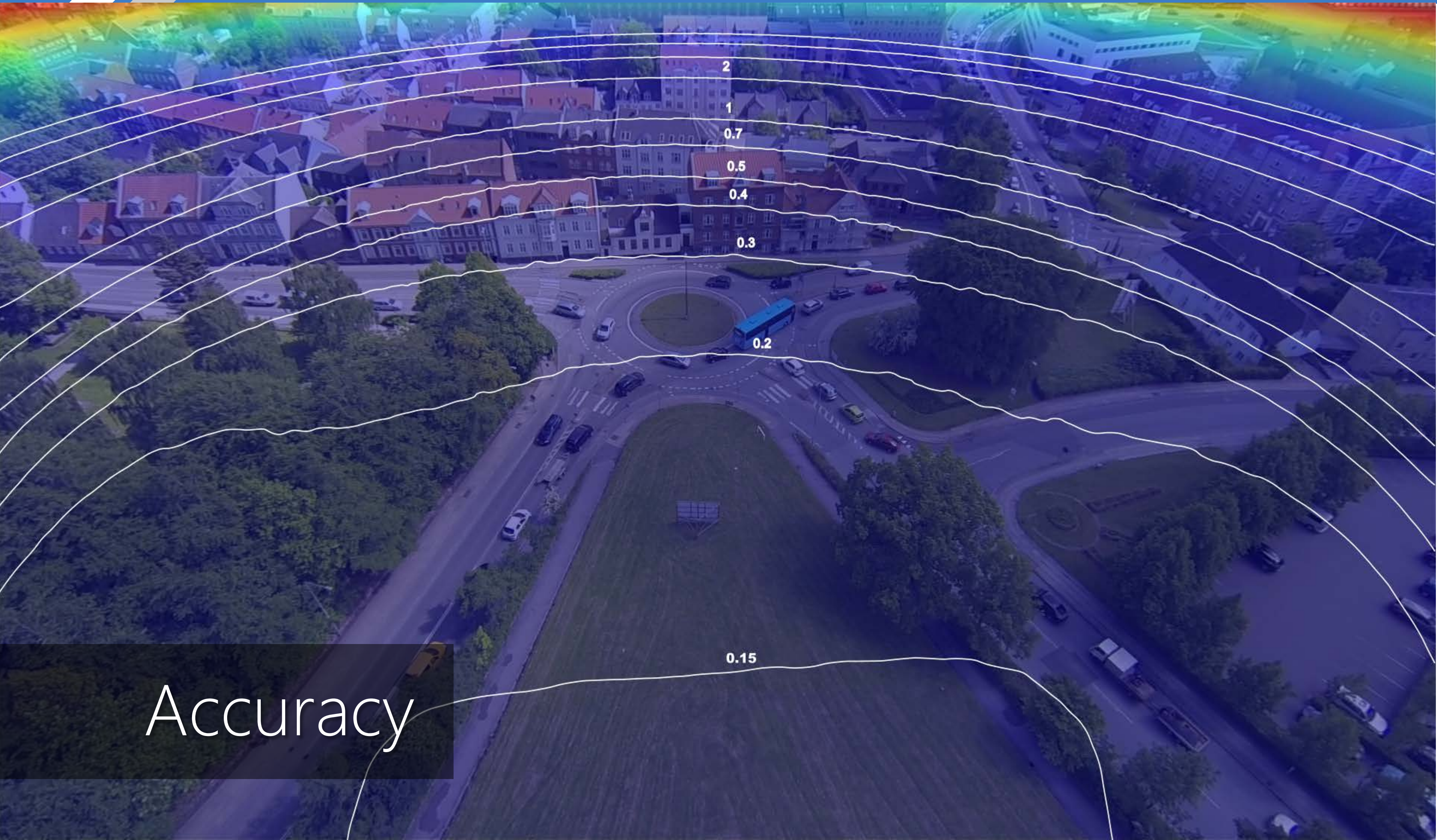
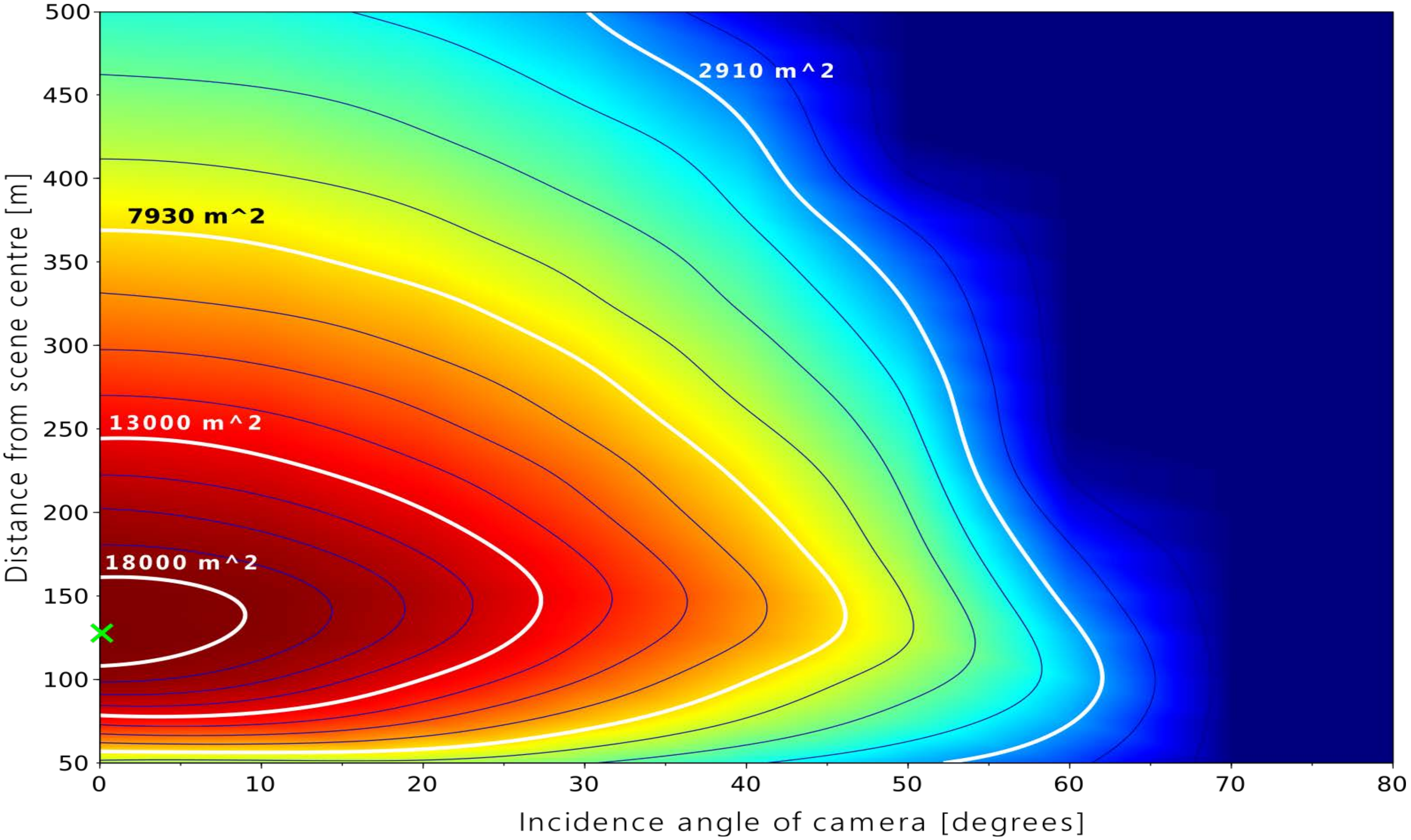


Accuracy


500
450
400
350
300
250
200
150
100
50
Distance from scene centre [m]
0
10
20
30
40
50
60
70
80
Incidence angle of camera [degrees]
2910 m^2
7930 m^2
13000 m^2
18000 m^2