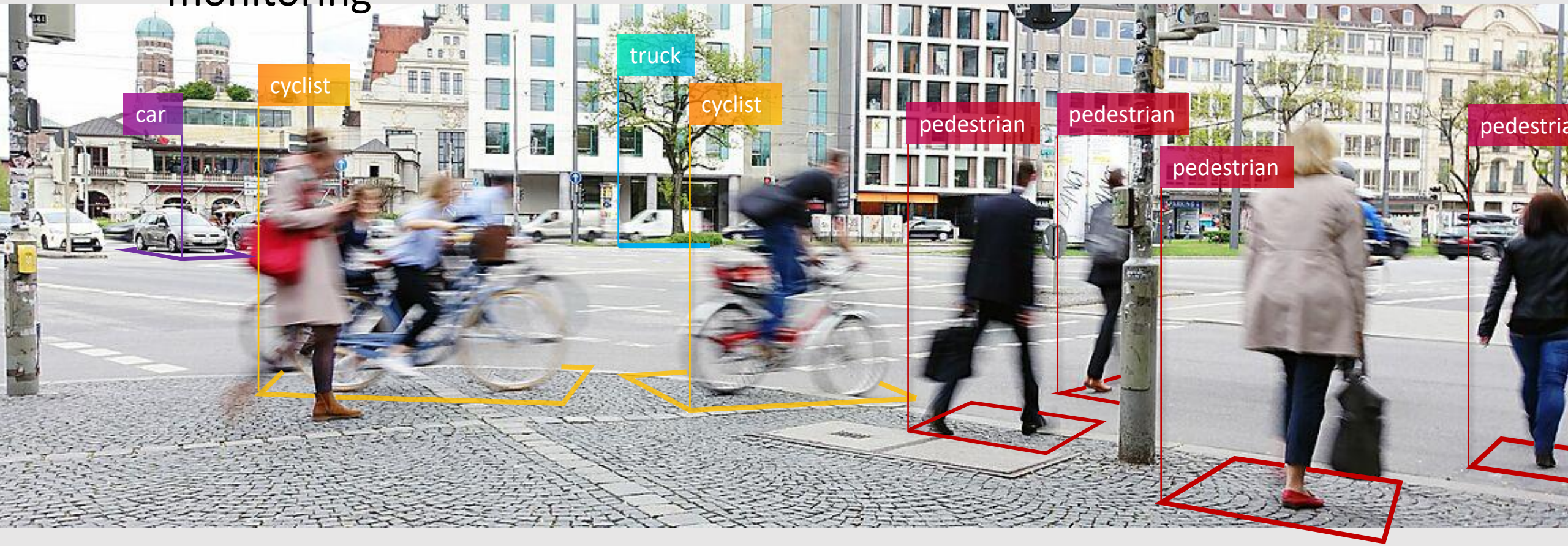
Radar-based traffic analysis in smart cities

Team 1

radarheads

In demand during the pandemic: anonymous, affordable traffic monitoring



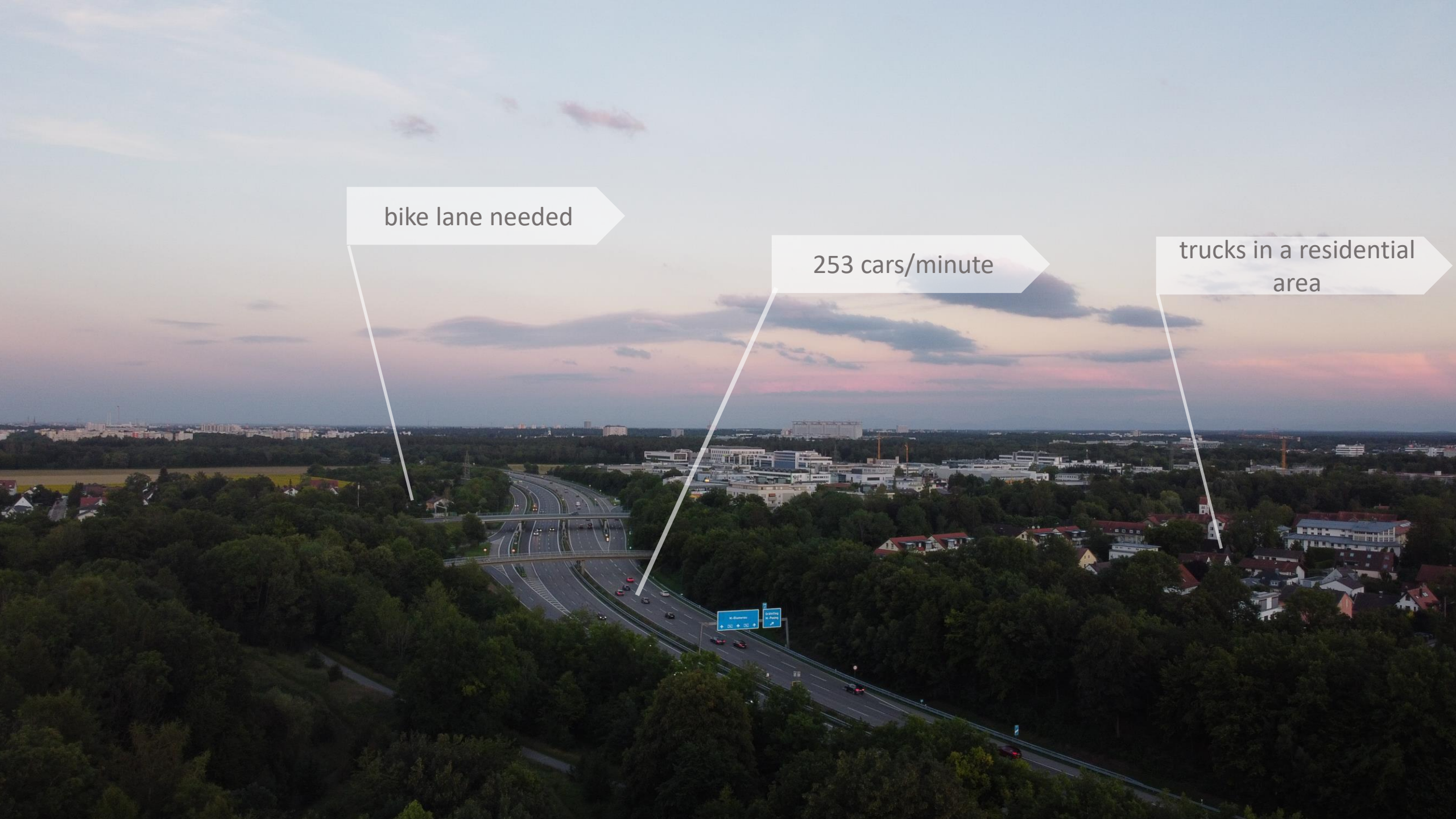
Application examples of radar

Easily acquired statistics of urban mobility, e. g. to monitor the spread of the pandemic and current willingness of the population to stick to the rules

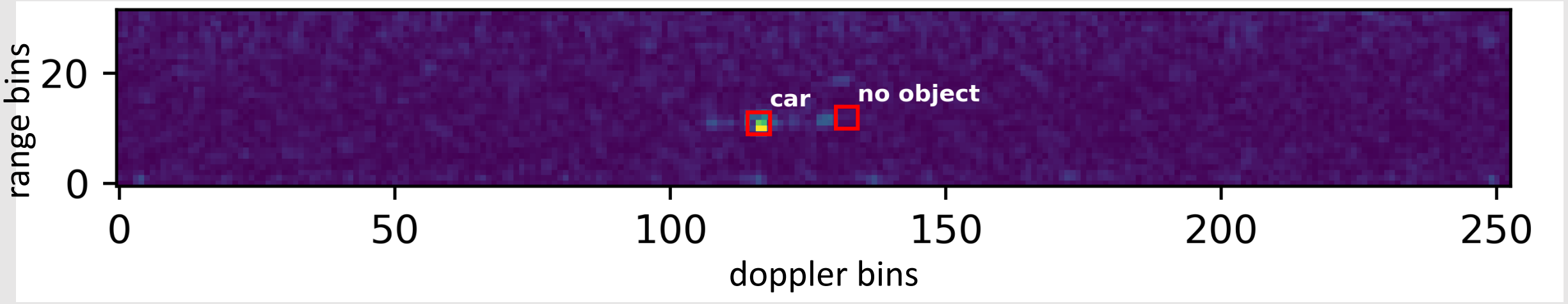
Tracking of bicycle traffic: where to build or not to build new bike lanes?

Smart traffic lights, safer & faster intersections

Dynamic highway use regulation depending on the time of the day

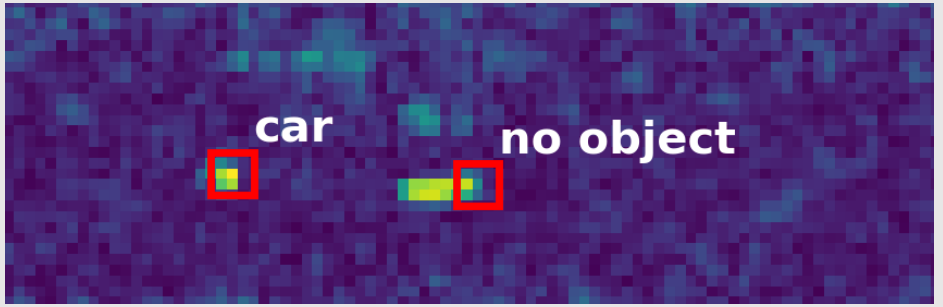

bike lane needed
253 cars/minute
trucks in a residential area

Visualization

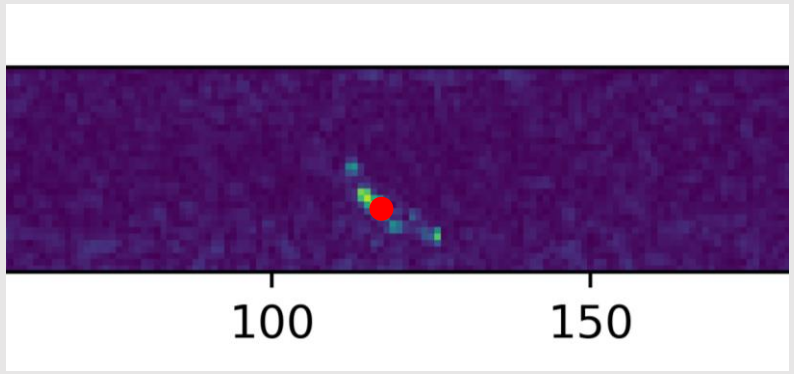


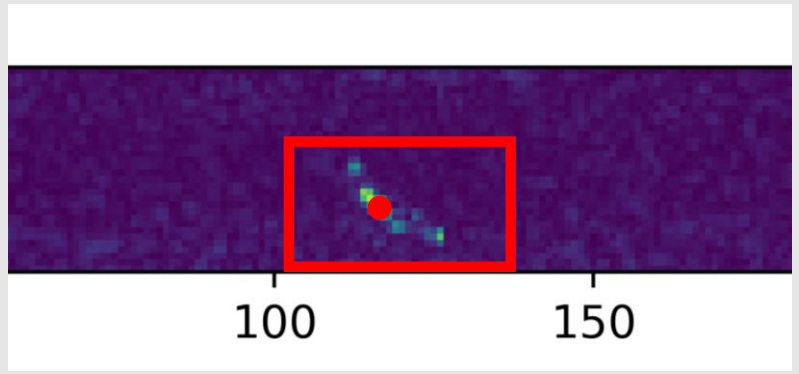
Data: challenges

- a very small dataset (375 radar maps, mostly one t
- overlapping boxes
- resolution often not sufficient for pedestrians
- the classes are not equally represented (5 pedestrians, 66 cars, 332 trucks)
- no directional information (only range)
- high noise background



Solution 1: decision tree on higher feature vectors

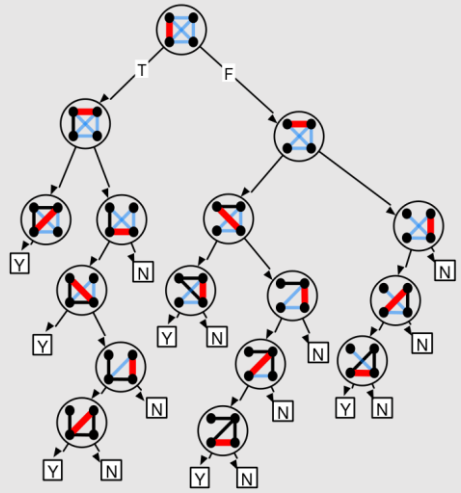




1. CFAR to detect peaks (preceded by Gaussian filter). Count objects

2. Place bounding boxes of uniform size around peaks

3. Extract higher feature vector containing box statistics

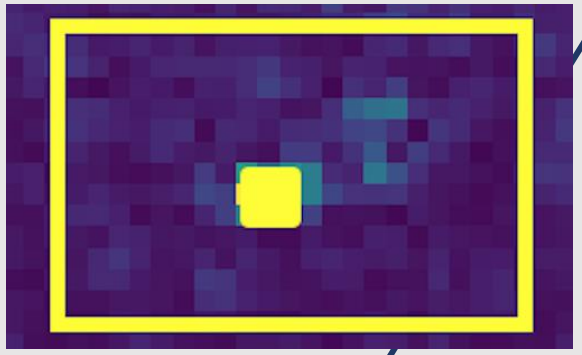


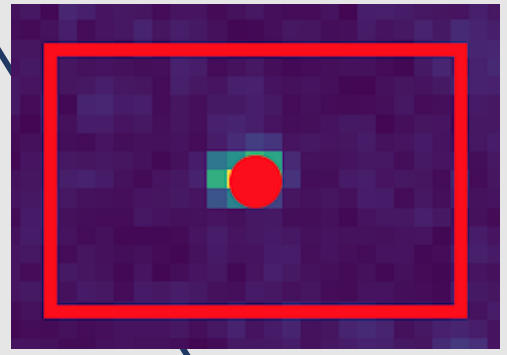
4. Train decision tree classifier on higher feature vectors

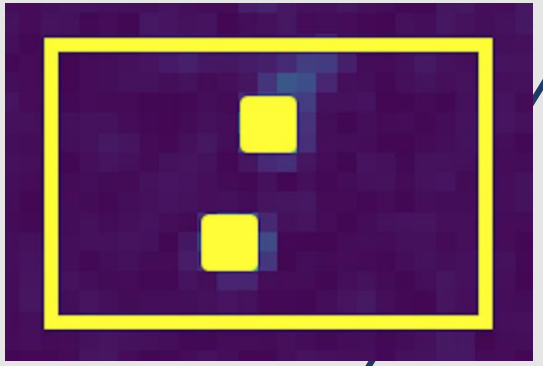
5. simultaneously evaluate object detection and classification

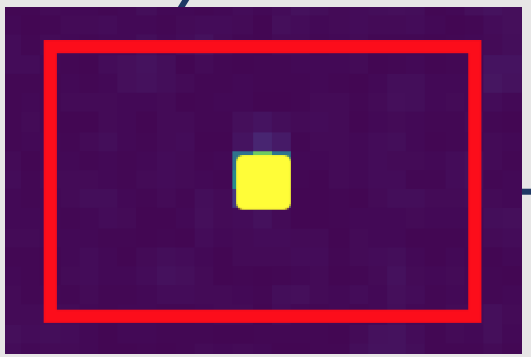
How is accuracy defined?

True positive

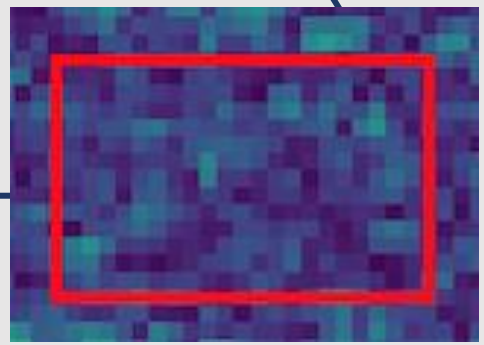


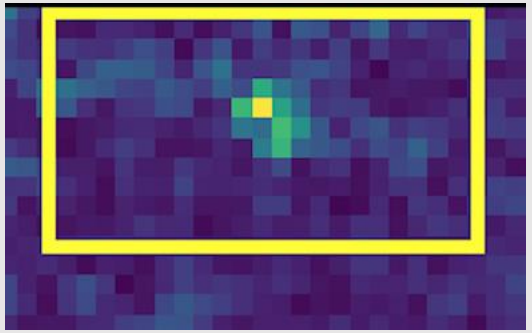






False positive



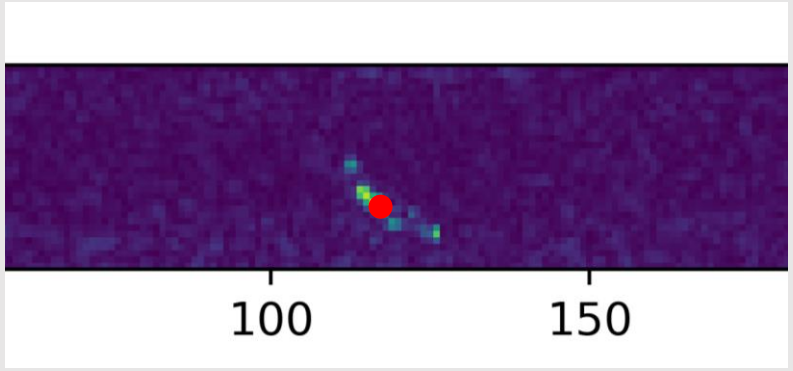


False negative

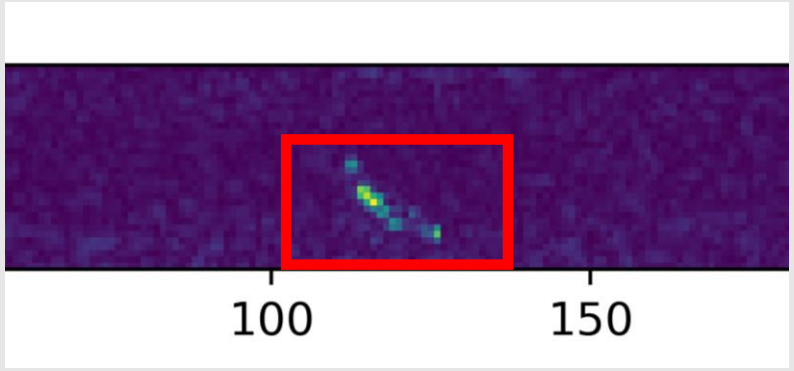
Solution 1: results

- Pure classifier accuracy: **92.9%**
- Detection + classification accuracy: **70.7%**
- Counting accuracy: **73.1%**

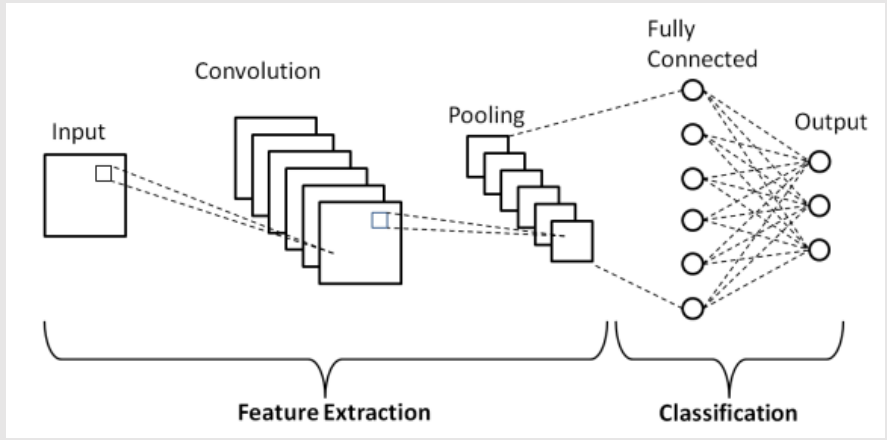
Solution 2: peak detection → CNN classification



1. Optional: detect peaks to generate bounding boxes, e.g. using DBscan



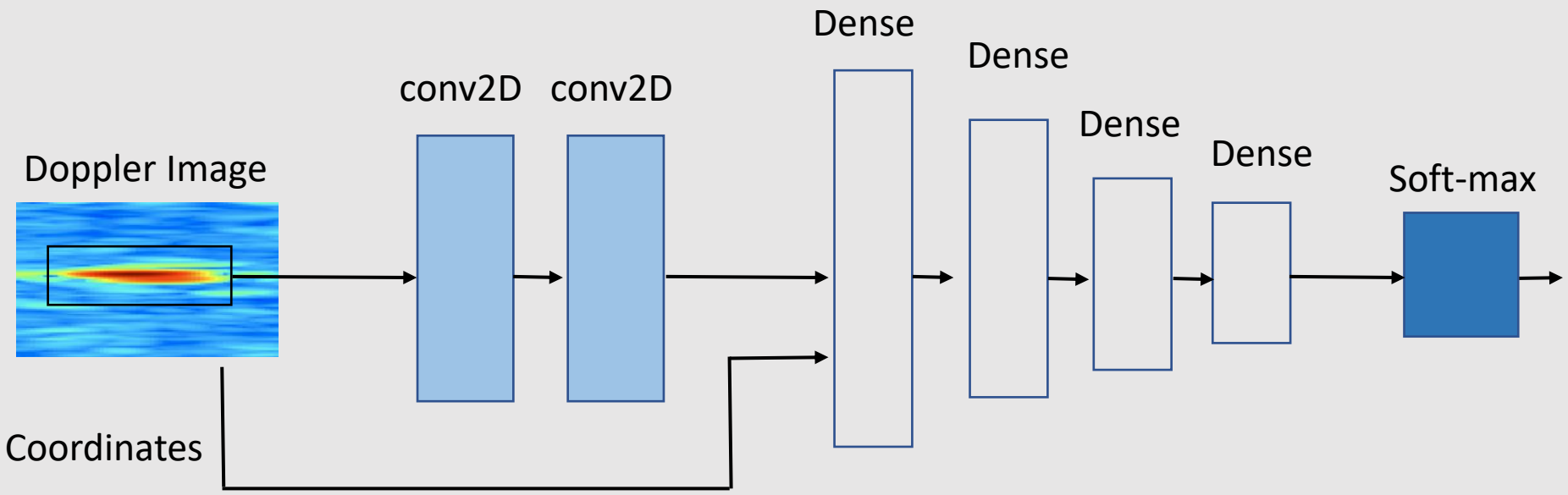
2. Pad bounding boxes of targets to make them uniformly sized

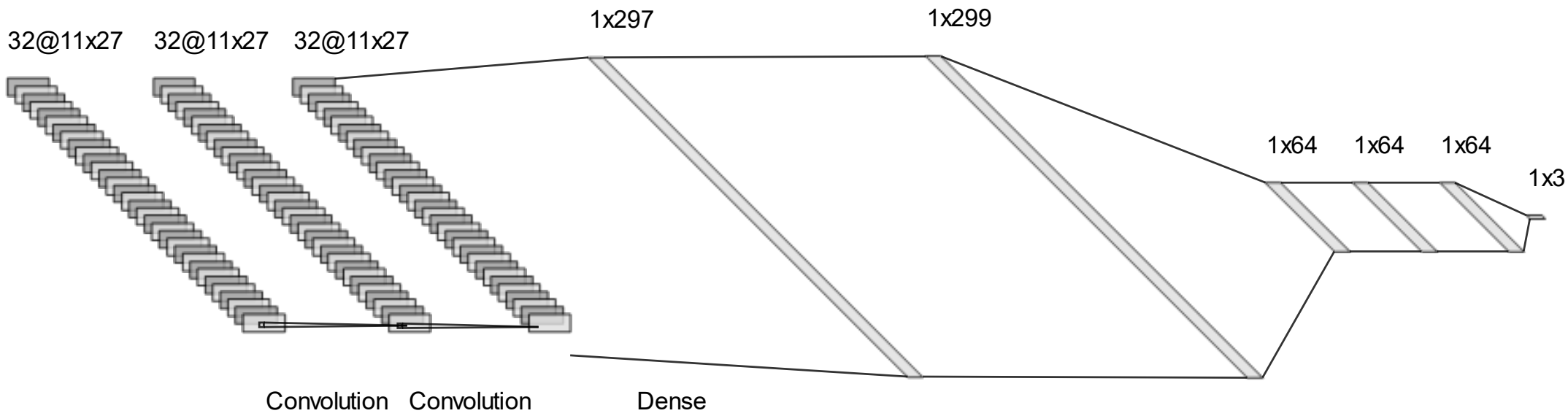


3. Apply CNN classifier to cutouts

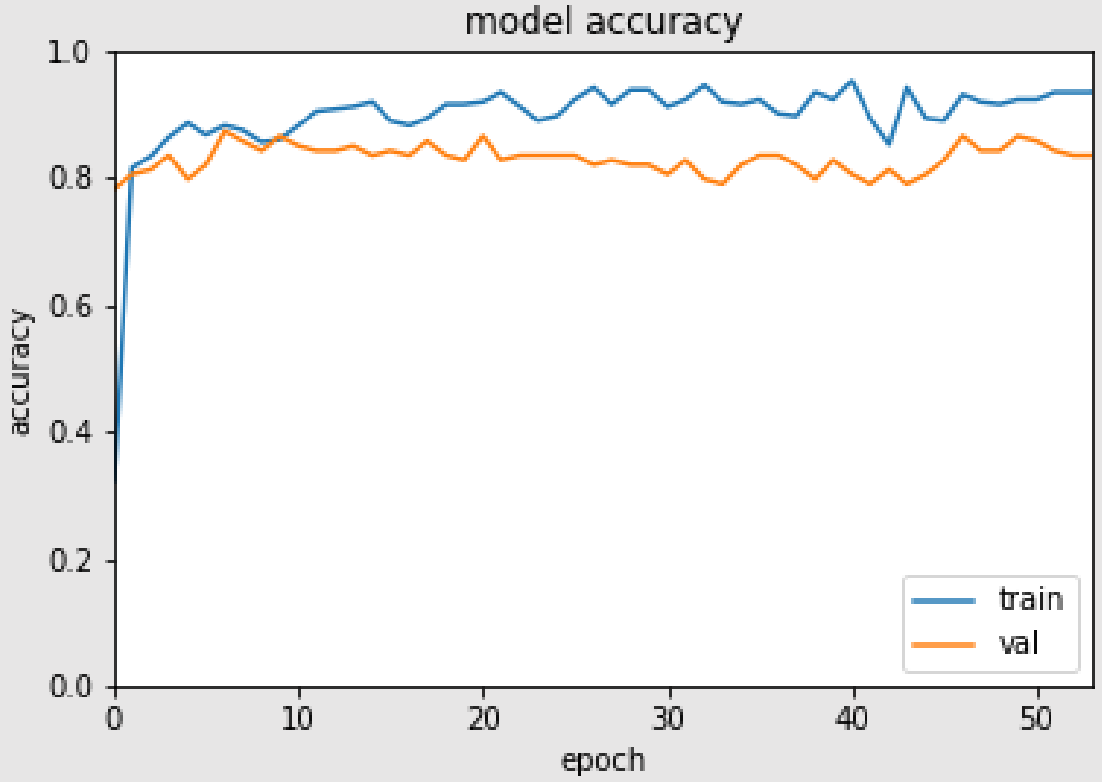
4. Result: Class 3 (truck)

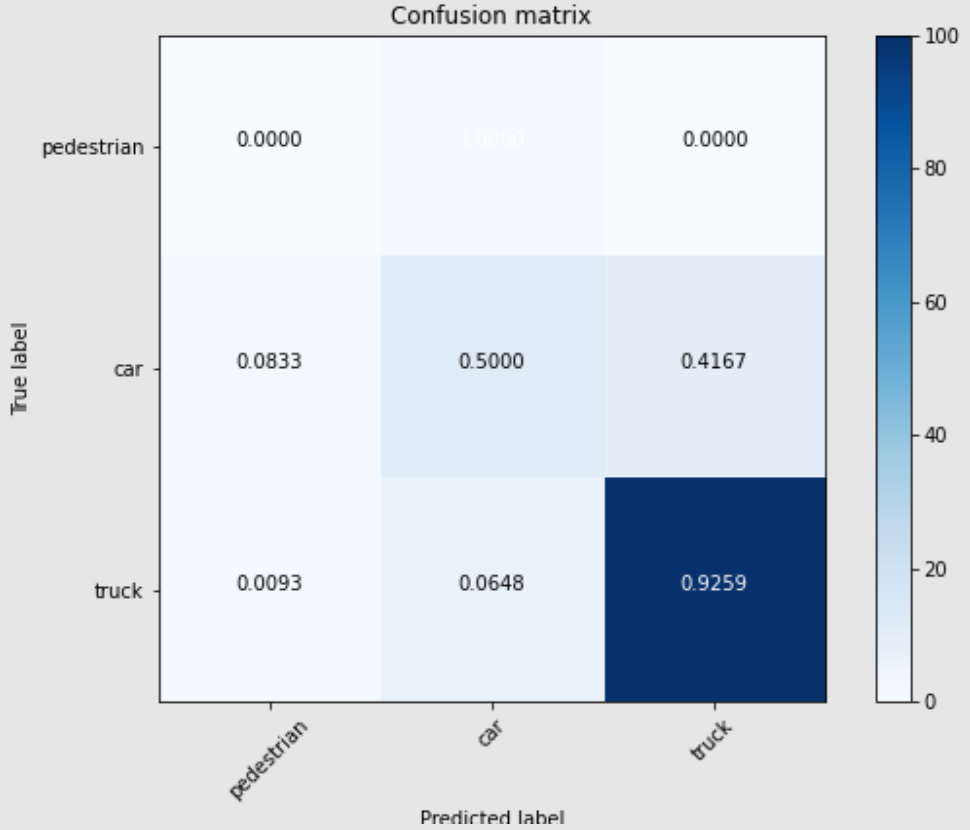
CNN architecture




32@11x27
32@11x27
32@11x27
1x297
1x299
1x64
1x64
1x64
1x3
Convolution
Convolution
Dense

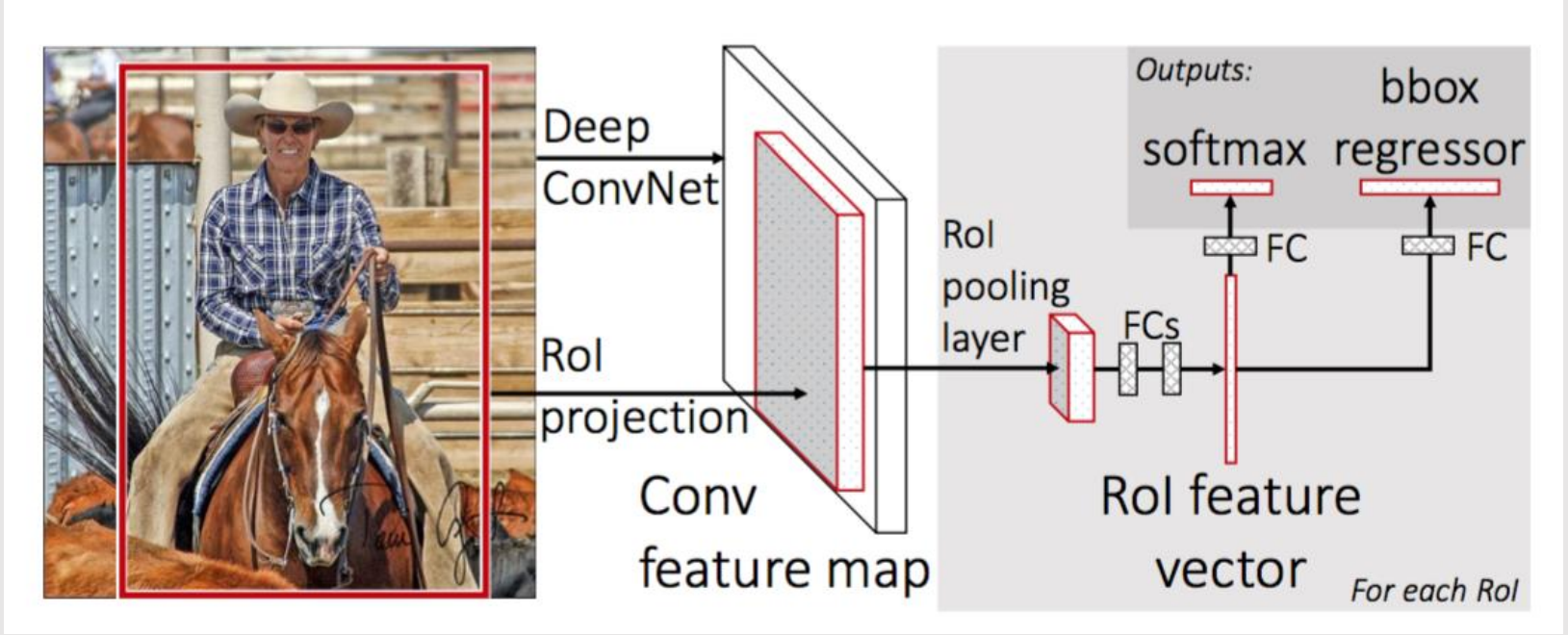
Solution 2: results





Solution 3: R-CNN for simultaneous detection and classification

- Problem: number and size of radar targets not fixed
- Solution: region based CNNs: region detection and classification
- We used: Fast R-CNN (2015)



Source: https://arxiv.org/pdf/1504.08083.pdf

Outlook and remaining tasks

- More pedestrians and cars needed in the data to test the classifiers
- More data needed to train Faster R-CNN. May need to change significant parts
- Bottleneck: error-prone peak detection.
- Solution: try new peak/blob detection algorithms, preprocessing of radar images in advance, or forego peak detection completely

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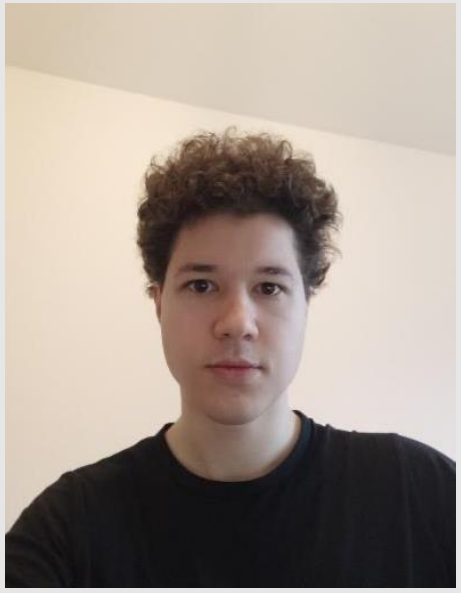

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