FROM BLACK-BOX TO WHITE-BOX: EXAMINING CONFIDENCE CALIBRATION UNDER DIFFERENT CONDITIONS

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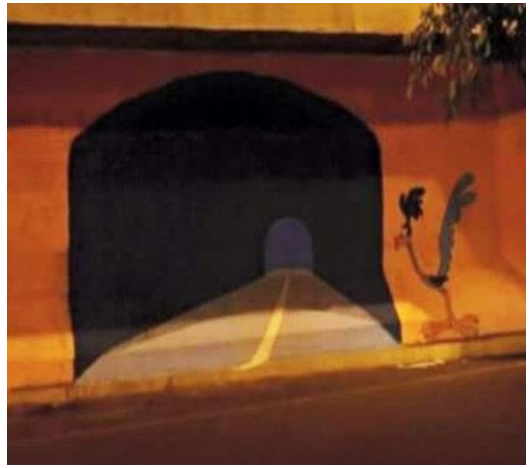
THE PERCEPTION CHALLENGE

Source: Towards a Framework to Manage Perceptual Uncertainty for Safe Automated Driving, Krzysztof Czarnecki and Rick Salay



BACKGROUND: CONFIDENCE CALIBRATION FOR CLASSIFICATION

Modern neural networks are overconfident [1]

Measurement of Miscalibration: *Expected Calibration Error* (ECE):

$$ECE = \sum_{n=1}^{N} \frac{|I(n)|}{|D|} \cdot |acc(n) - conf(n)|$$

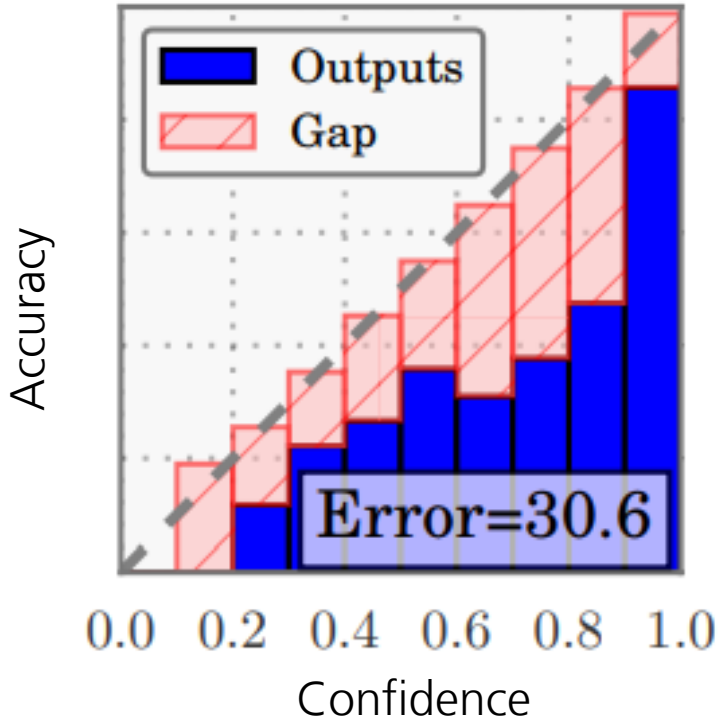
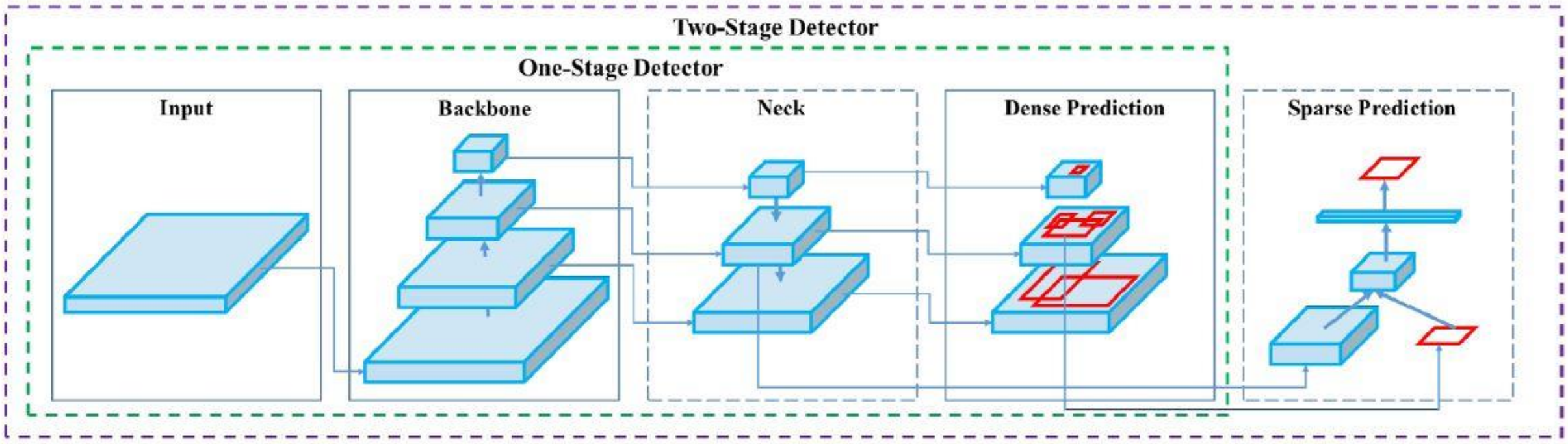


Fig. 1: Reliability Diagram of a 110-layer ResNet on CIFAR-100 [1]

OBJECT DETECTION PIPELINE



A Bochkovskiy et. al, Yolov4: Optimal speed and accuracy of object detection

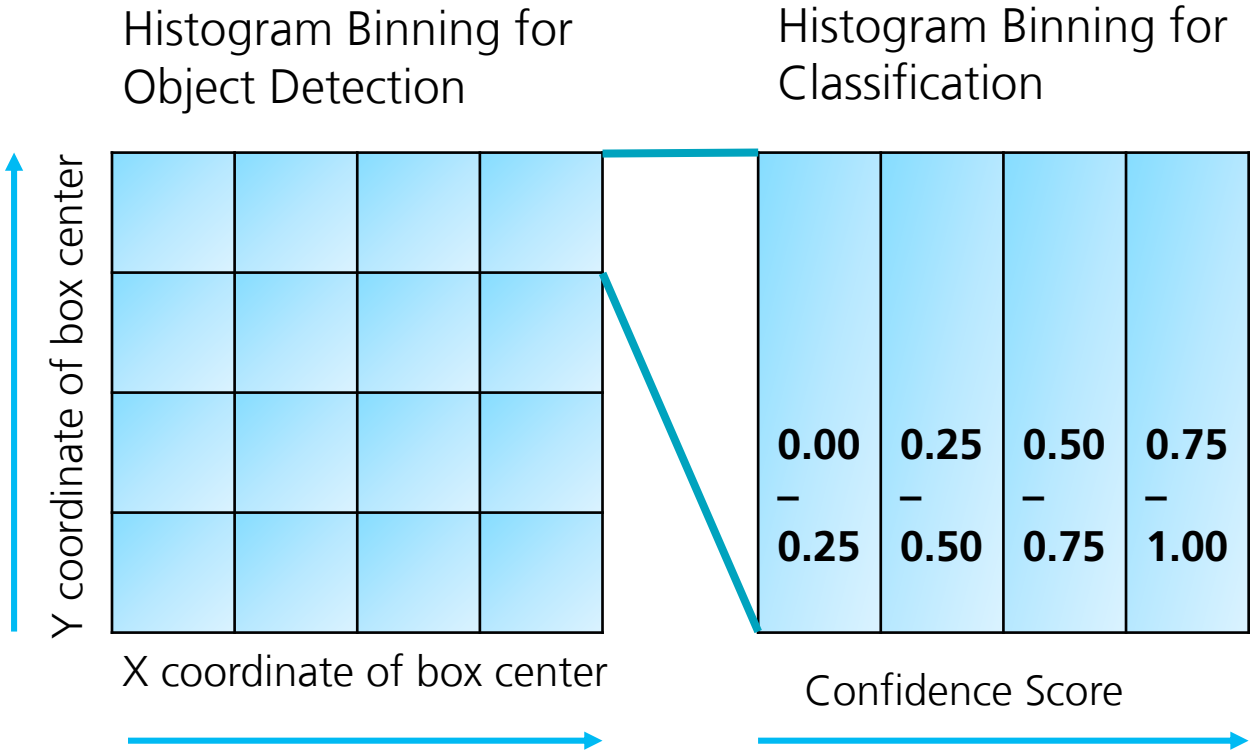
BACKGROUND: CONFIDENCE CALIBRATION FOR OBJECT DETECTION

Modern object detectors are also not well calibrated [2]

Measurement of Miscalibration:

Detection Expected Calibration Error (D-ECE):

$$D - ECE_K = \sum_{n=1}^{N_{total}} \frac{|I(n)|}{|D|} \cdot |prec(n) - conf(n)|$$



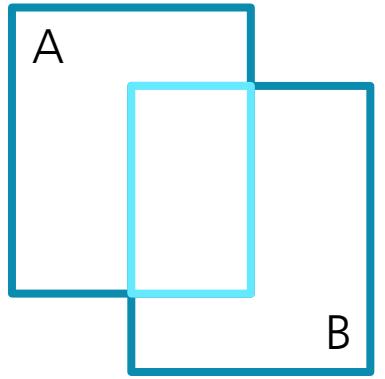
Going from 1D Histogram Binning to multi-dimensional Histogram Binning

BACKGROUND: NON-MAXIMUM-SUPPRESSION (NMS)

Method: selects a single bounding box with the highest confidence score out of many overlapping bounding boxes

Intersection over Union (IoU): controls how aggressively overlapping boxes are discarded

$$IoU(A,B) = \frac{A \cap B}{A \cup B}$$



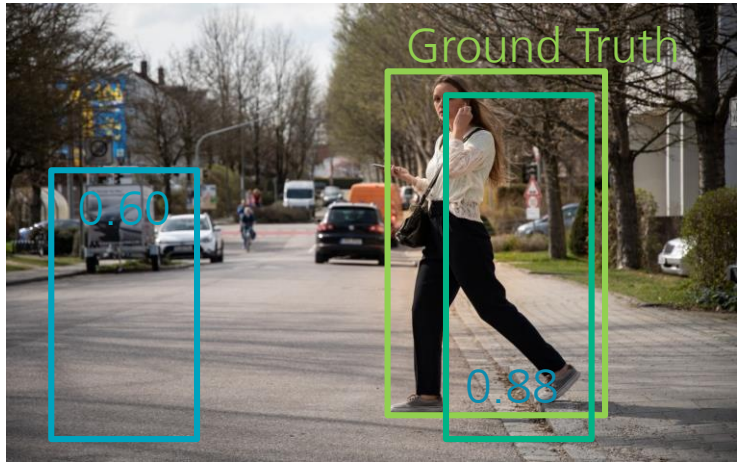
WHITE-BOX VS. BLACK-BOX

$$\text{TP: } IoU(\square, \square) \geq threshold$$

$$\text{FP: } IoU(\square, \square) < threshold$$

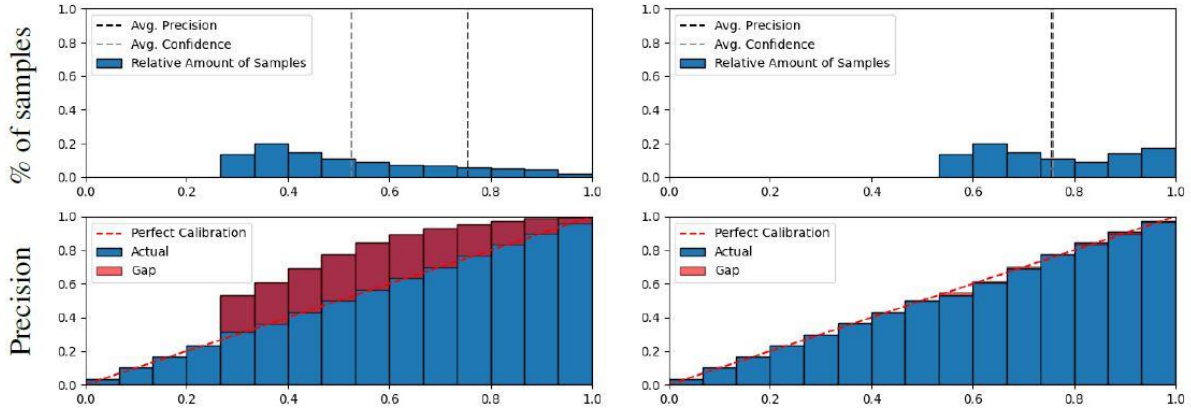
Miscalibration of object detectors is measured before (white-box) and after (black-box) NMS

Training and evaluation is done on the COCO2017 validation dataset



WHITE BOX CALIBRATION RESULTS

RetinaNet



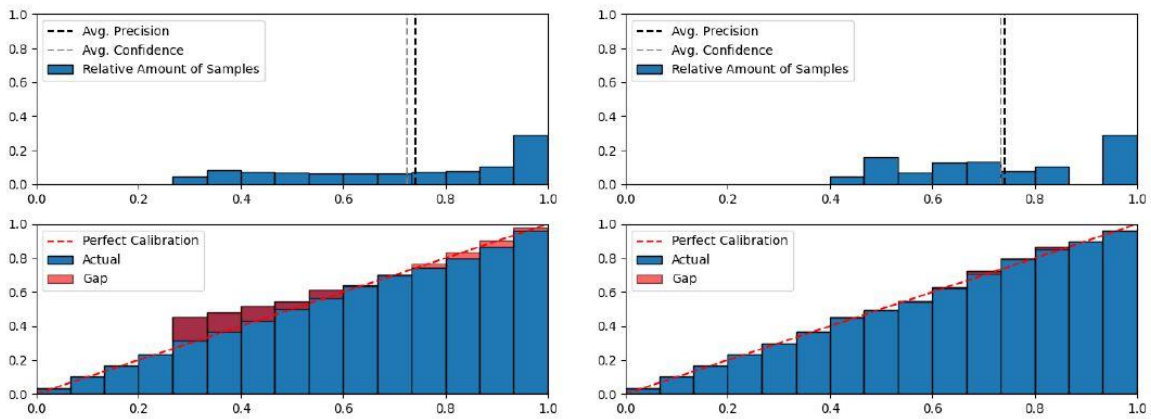
Before

Uncalibrated D-ECE:
22.9%

After

Calibrated D-ECE:
0.981%

Faster R-CNN



Before

Uncalibrated D-ECE:
4.20%

After

Calibrated D-ECE:
0.861%

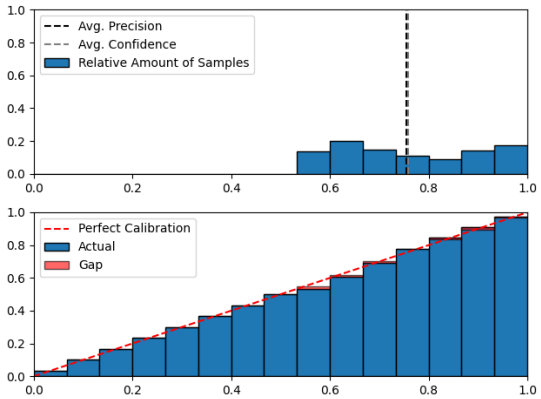
Fraunhofer IKS

QUALITATIVE RESULTS

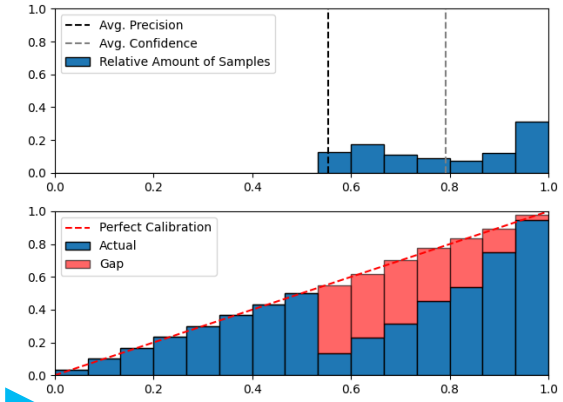
NMS potentially degrades initially well-calibrated predictors

After white-box calibration

Confidence Histogram (top) and Reliability Diagram (bottom) of RetinaNet

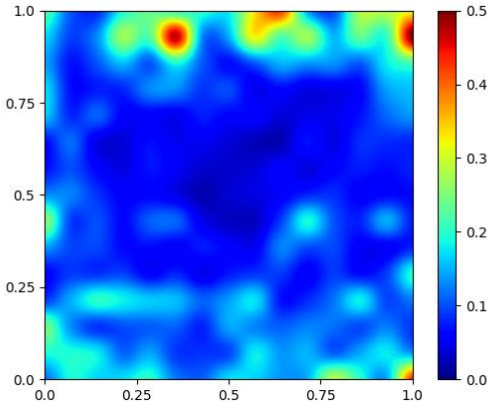


NMS

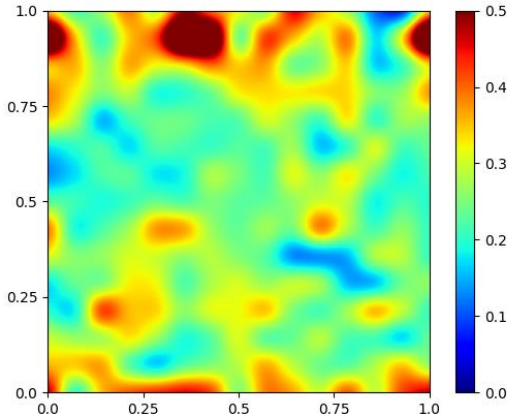


Position-dependent Heatmap of RetinaNet

D-ECE



D-ECE



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CONCLUSION

- Focal loss decreases average confidence
- White Box Calibration works
- NMS making predictions overconfident
- Detections on border of image tend to be worse calibrated than near the center
- Future work should focus on other box aggregation methods than NMS (e.g. average boxes)

REFERENCES

All quantitave calibration results are given in our paper in more detail.

References

[1] Chuan Guo, Geoff Pleiss, Yu Sun, and Kilian Q. Weinberger.

On Calibration of Modern Neural Networks.

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[2] Küppers, F.; Kronenberger, J.; Shantia, A.; and Haselhoff, A. ¨ 2020.

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In Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops, 326–327.