KI WISSEN
Automotive AI Powered by Knowledge

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Interpretable Model-Agnostic Plausibility Verification for 2D Object Detectors Using Domain-Invariant Concept Bottleneck Models

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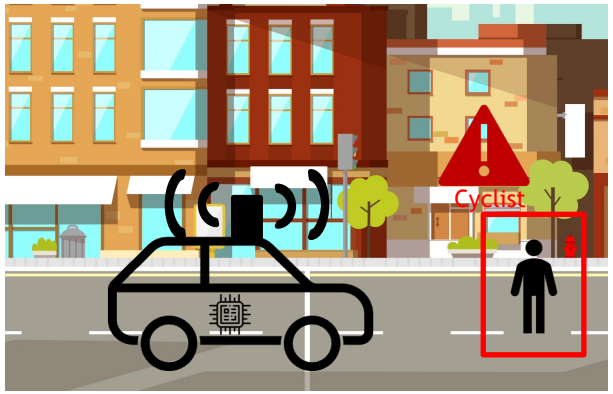
Motivation

Questions:

- How can we check the plausibility of DNN-based perception functions?

Requirements:

- Post-Hoc (Model-Agnostic)
- Operation-Time (Small & Cheap)
- Human-Interpretable
- Robust (In particular, domain invariant)

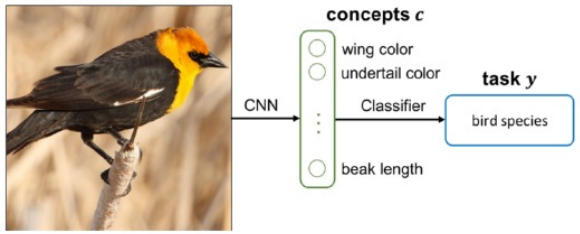


EU AI ACT:

- Under Title VIII „Post-Market Monitoring“ for high-risk AI
- Post-market monitoring requires **error (incident) monitoring** functionality. For this, one has to **identify incidents (implausible behavior) during operation.**

Concept-Bottleneck Models

x -> model - > y



(Koh, Concept Bottleneck Networks, 2020)

- **Challenges:**
  - Requires densely-labeled datasets
- **In Literature:**
  - Significant and extensively studied
    - Belem, Weekly Supervised Multi-Task Learning for Concept-Based Explainability, ICLR, 2021
    - Bento, ConceptDistil: Model Agnostic Distillation of Concept Explanations, ICLR, 2022
    - Sawada, Concept Bottleneck Model With Additional Unsupervised Concepts, IEEEAccess, 2022
    - Yuksekgonul, Poikarinen, Label-Free Concept Bottleneck Models, ICLR, 2023
    - Post-Hoc Concept Bottleneck Models, ICLR, 2023

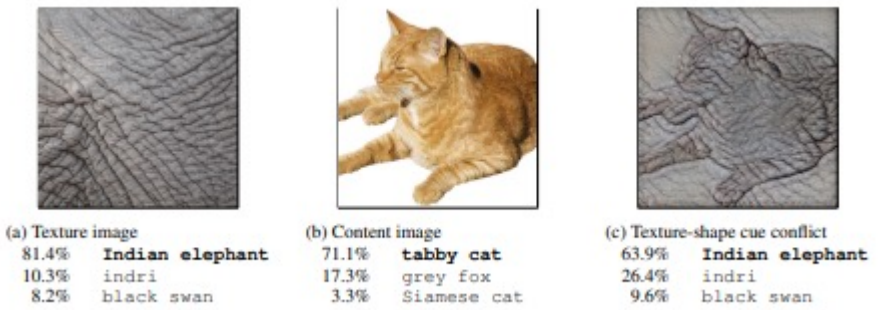
Concept-Bottleneck Models

- **Our Solution:**
  - Transfer Learning

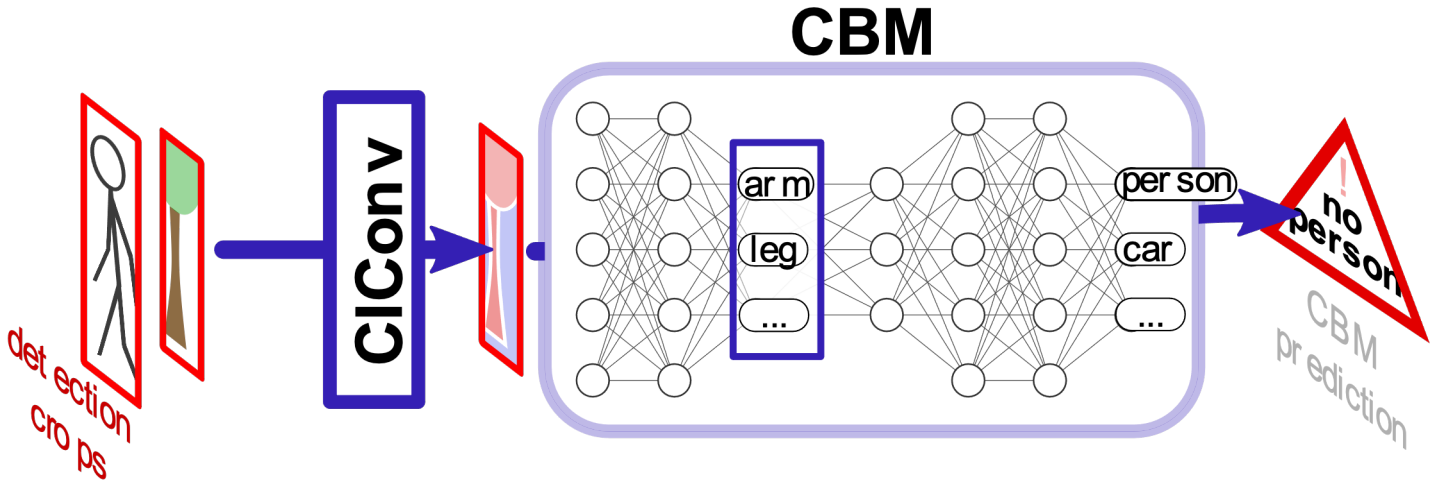
(Broden, ECCV 18)

- **Challenge:**
  - How can it perform well in diverse scenarios?

GIF courtesy of Waymo Open Dataset*

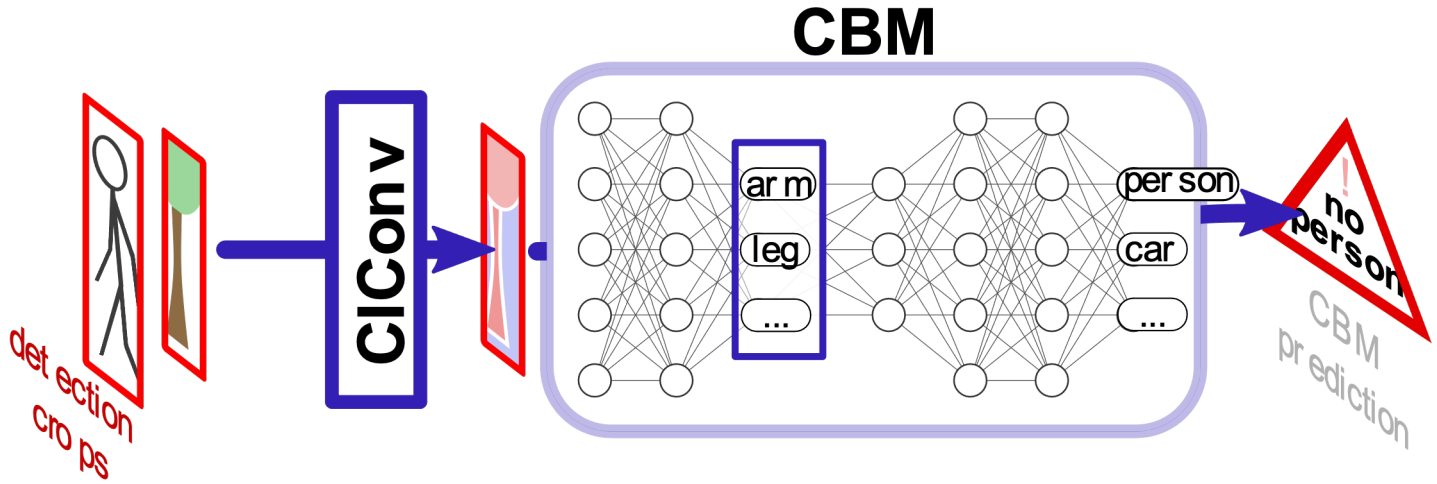


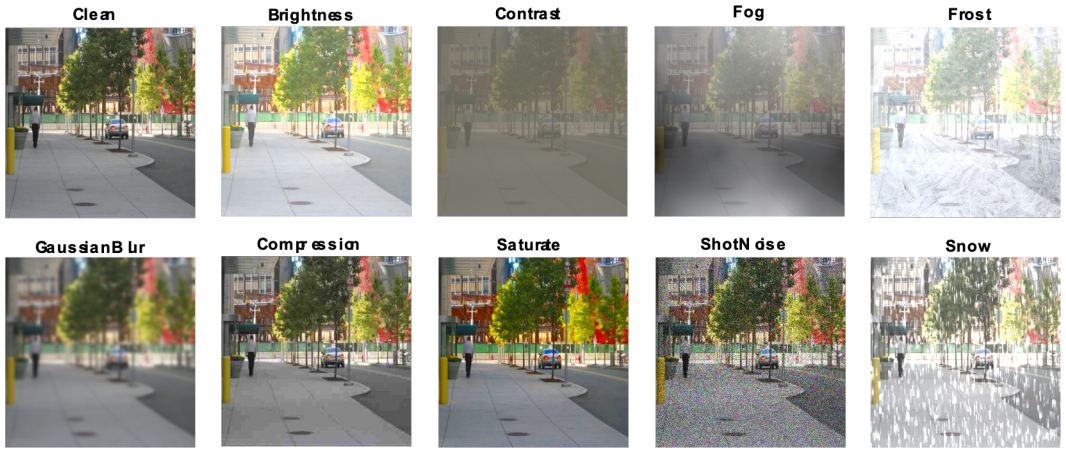
Robust, Generalizable Representations



- Lengyel et. Al., Zero-Shot Day- Night Domain Adaptation with a Physics Prior, ICCV, 2021
- Geirhos et. Al., ImageNet-Trained CNNs are Biased Towards Texture; Increasing Shape Bias Improves Accuracy and Robustness, ICLR, 2019

Learning Robust Concept Representations



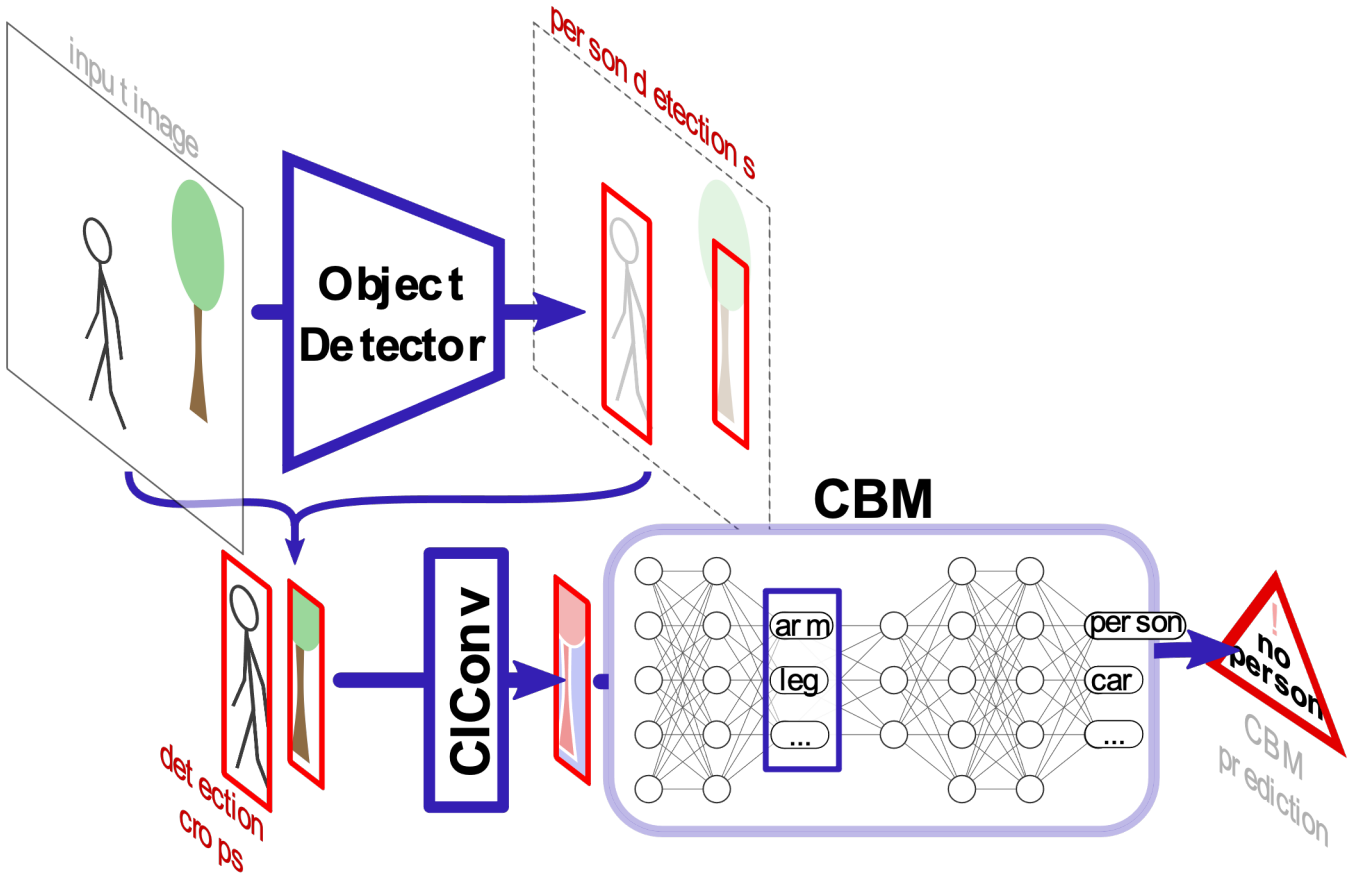


Perturbed Test Dataset of Broden

	Person		Car	
Corruptions	CBM	CIConv-CBM	CBM	CIConv-CBM
Clean	**89.3%**	87.4%	**91.4%**	90.3%
Brightness	33.88%	**85.69%**	64.92%	**88.77%**
Contrast	33.03%	**85.60%**	52.17%	**87.46%**
Fog	34.62%	**84.74%**	69.38%	**87.30%**
Frost	34.9%	**74.84%**	69.50%	**80.12%**
Gaussian Blur	35.16%	**75.19%**	70.04%	**81.73%**
Compression	35.06%	**83.84%**	69.74%	**87.55%**
Saturate	34.91%	**85.65%**	68.89%	**89.27%**
Shot Noise	34.27%	**65.53%**	42.13%	**74.55%**
Snow	35.27%	**65.37%**	68.33%	**77.90%**

Table 3. Object class prediction accuracy comparison between vanilla CBM and CBM with CIConv layer on Broden test data with applied corruptions (severity=3). Bold numbers highlight the best prediction performance for each class and corruption type.

FPs Monitoring with Color-Invariant CBMs



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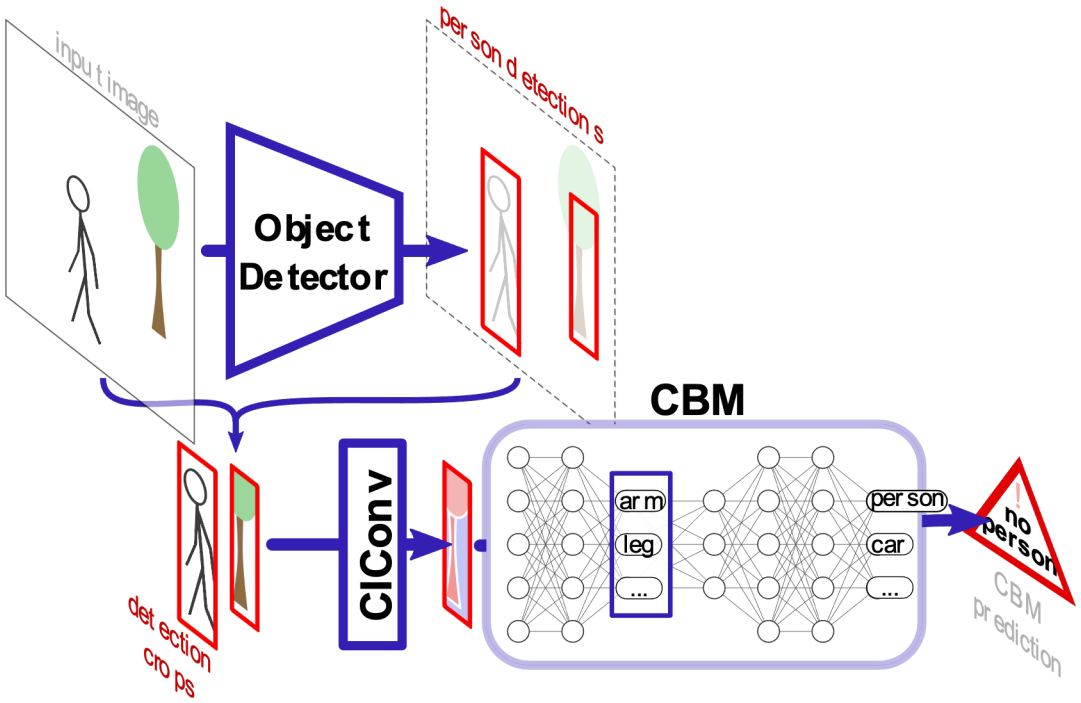
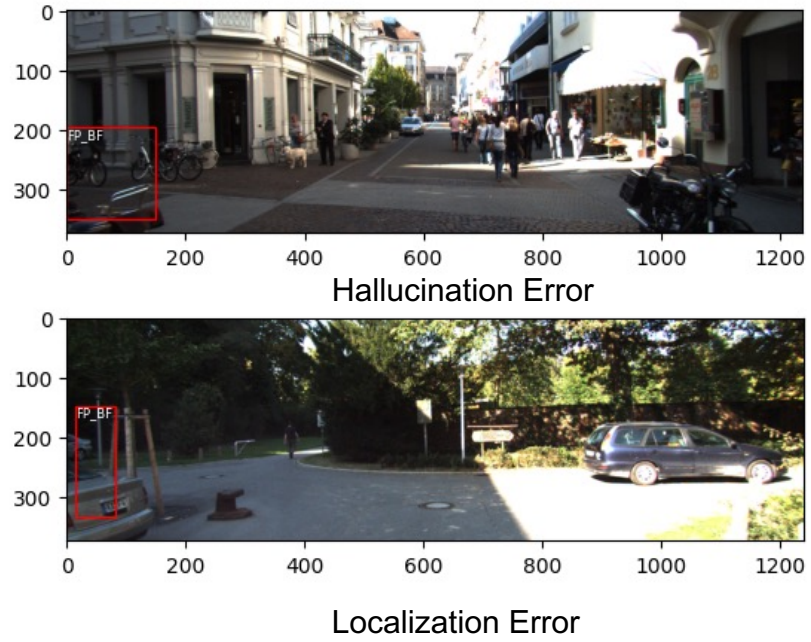


Data, Model	Task	IoU	Precision	Recall
KITTI, SDet	Car	0.7	**0.96**	0.07
KITTI, SDet	(F) Car	0.7	0.81	**0.56**
KITTI, SDet	Ped	0.5	**0.83**	0.01
KITTI, SDet	(F) Ped	0.5	0.72	**0.95**

Table 4. Comparison of fine-tuning (FT) and zero-shot false positive monitoring for SqueezeDet (SDet) on KITTI easy

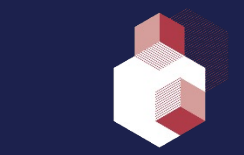
FPs



- Keser, Mert, et al. "Interpretable Model-Agnostic Plausibility Verification for 2D Object Detectors Using Domain-Invariant Concept Bottleneck Models." *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*. 2023.

Conclusion & Future Work

- We proposed a novel method for model-agnostic, robust, flexible, and human interpretable operation-time plausibilisation of object detector detections.
- Exploring the potential of this monitoring approach in identifying and addressing other types of object detection errors, particularly focusing on false negatives.



Questions

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