High Dynamic Range in Computer Vision

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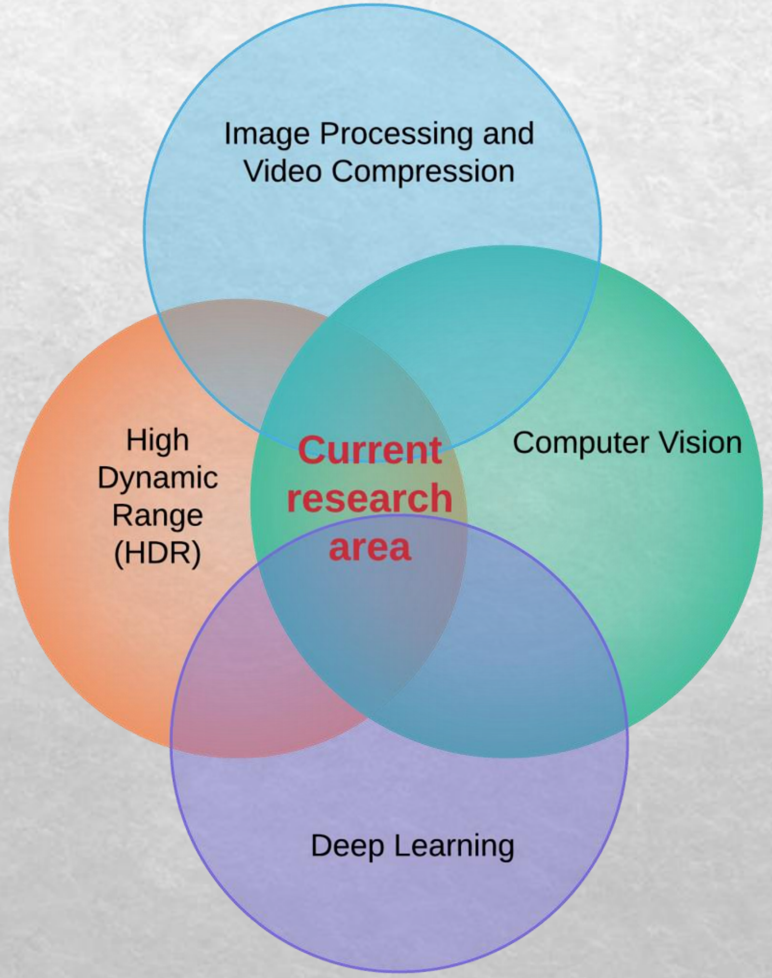
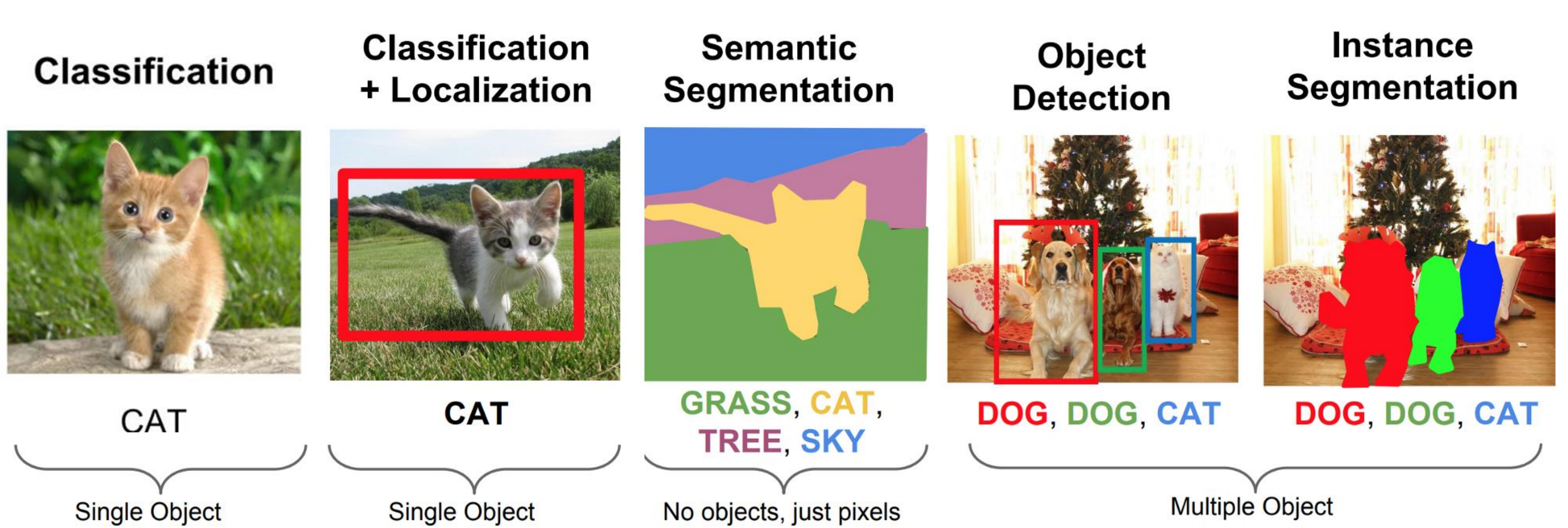
Research scope



- High Dynamic Range (HDR) in object detection encompasses
    1. High dynamic range image and video processing
    2. Explore traditional object detection and tracking techniques.
    3. Deep learning based:
        - Image generation (generative NNs)
        - CNN based object detection.

A few important tasks in Computer Vision



Some standardized datasets

Classification:

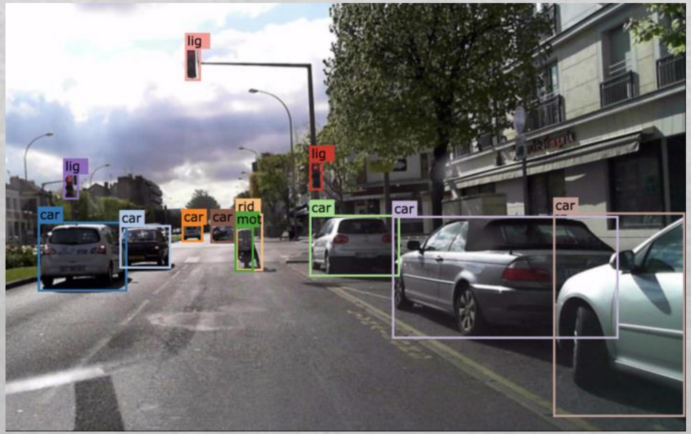
- CIFAR 10 and 100
- Stanford cars
- ImageNet
- Open Images Dataset
- FER 2013 (emotion classification)

Object Detection:

- PASCAL VOC (2007 + 2012)
- MS COCO
- ILSVRC (detection subset)
- Open Images Dataset (subset)
- BDD100K

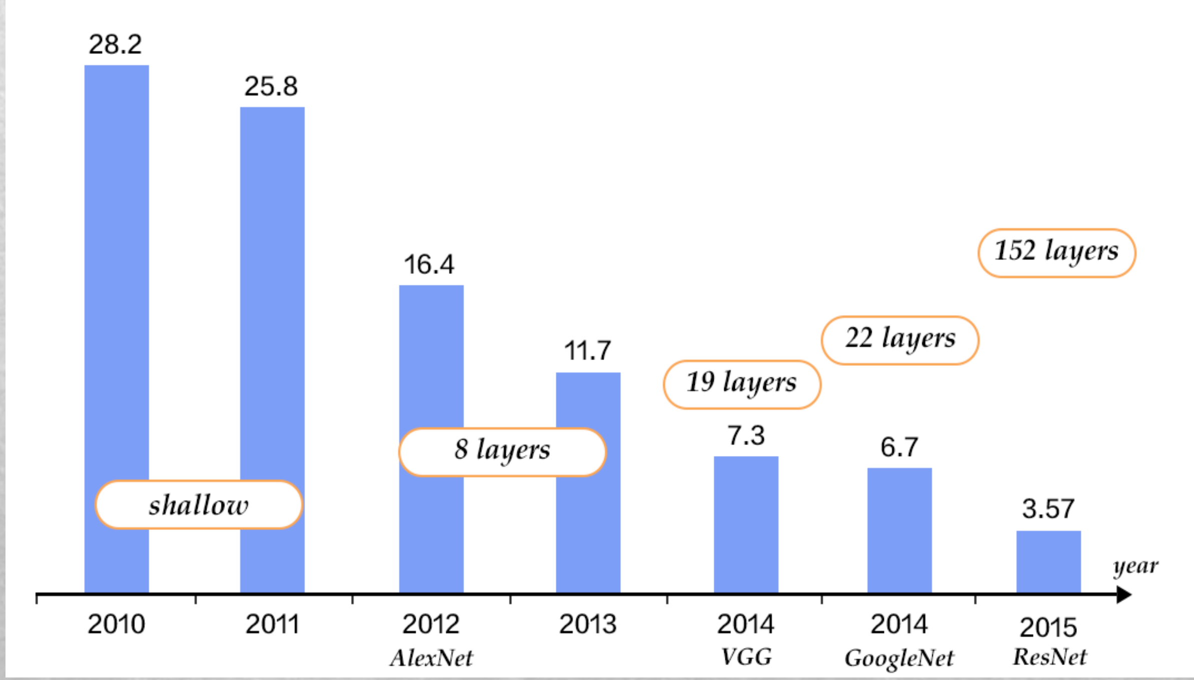
Semantic segmentation:

- CamVid
- KITTI
- CityScapes
- Mapillary
- BDD100K



Some state-of-the-art results (using deep learning)

- The introduction of deep neural networks (AlexNet, 2012) have changed the whole paradigm in computer vision with near human levels of accuracy.



Large scale **image classification** (error rate)

Algorithm	Dataset	mAP [AP 50]
SSD	Pascal VOC (07 + 12)	82.2
Faster RCNN	Pascal VOC (07 + 12)	75.9
R-FCN	Pascal VOC (07)	82.0
YOLO v2	Pascal VOC (07)	78.6
SSD	MS COCO (15)	48.5
YOLO v2	MS COCO (15)	44.2
Mask R-CNN	MS COCO (16)	63.2
CenterNet	MS COCO (15)	50.30

Large scale **object detection** (mAP)

The state-of-the-art results are scarily good…

So what is left to do ?

We shall see in the next slides…

So where do computer vision algorithms fail?

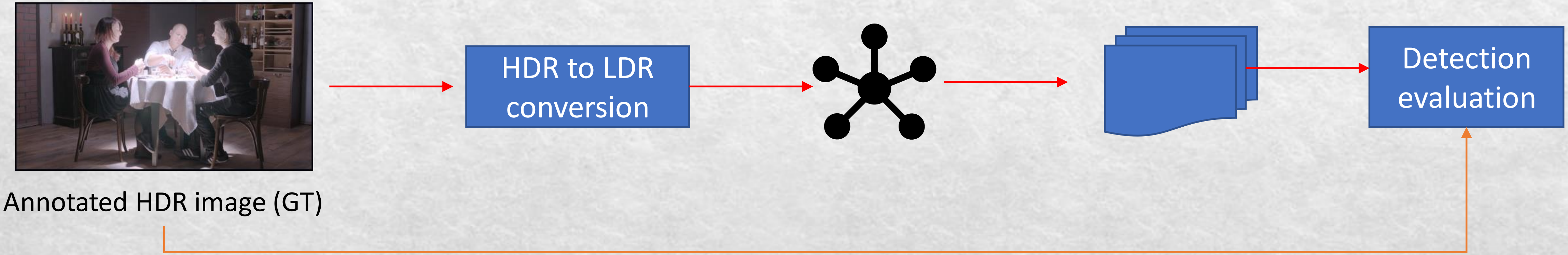
- Computer vision algorithms are mostly trained on LDR images i.e. 3 orders of magnitude of ambient lighting conditions.

- The limited DR in 8-bit data:
  - Fails to capture information in underexposed or overexposed scenarios.
  - Adverse conditions – (imagine night → blizzard)
  - High contrast scenarios
  - Rapidly changing lighting conditions (imagine tunnel)

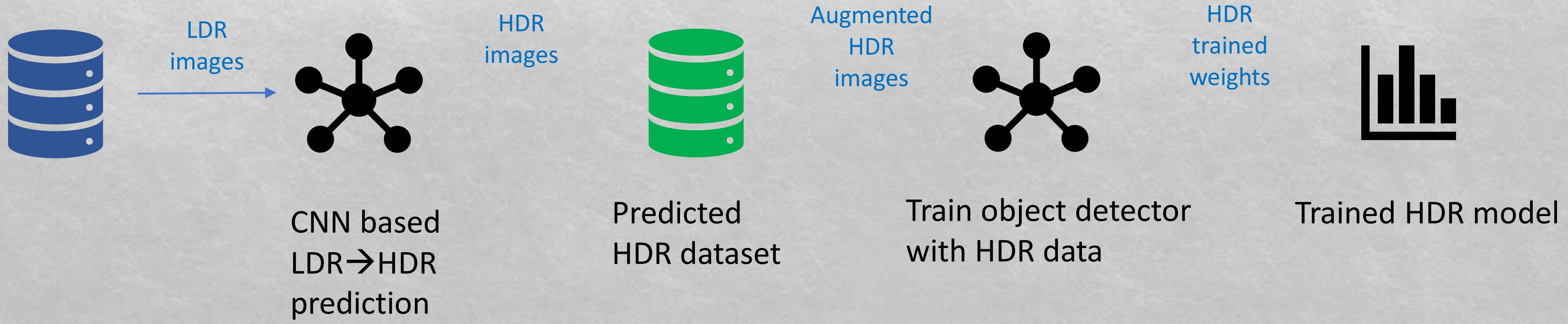
Example: extreme lighting condition leading to partial occlusion.

Research approach

1. Approach 1: Backward compatible HDR object detection using existing detectors



2. Approach 2: Generate HDR data and train HDR object detectors



But we have a BIG !! data problem

≈ 2000 HDR images are freely available from various sources

≈ 3000 HDR images (mobile photo-burst) are available from Google HDR dataset

≈ 50 usable HDR video sequences (5-10 secs) are available.

All classification, detection and segmentation datasets are 8-bit LDR datasets

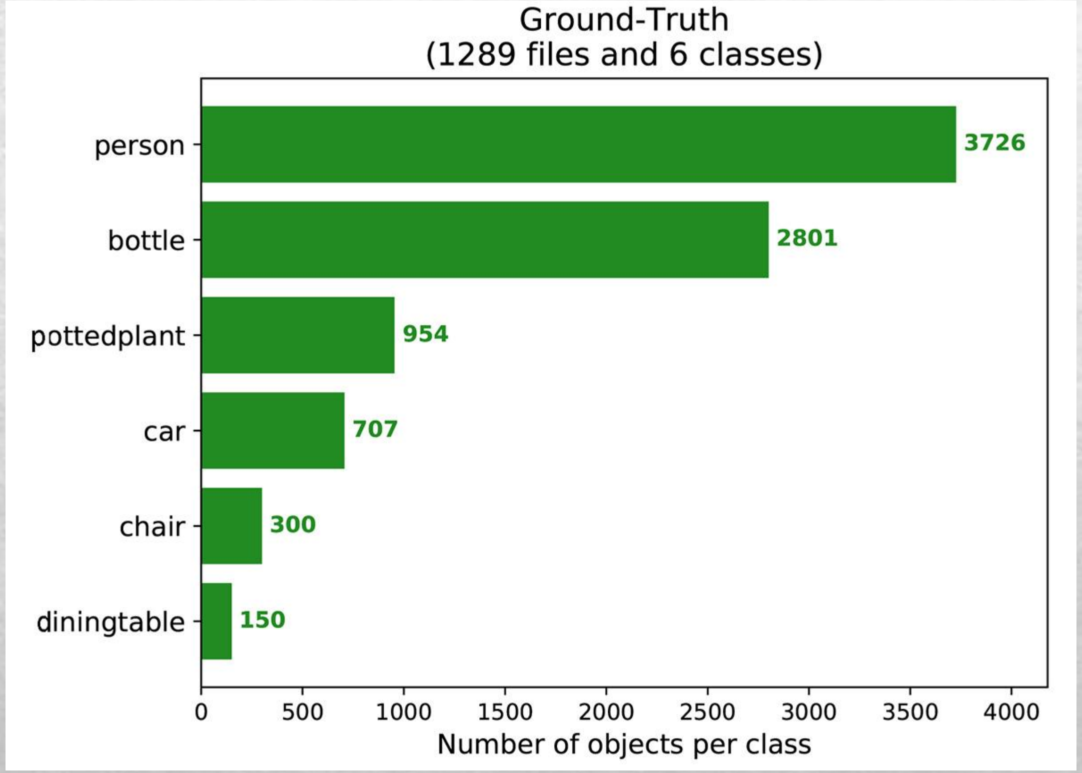
PART – I :
Dataset generation






Creation of mini-HDR dataset (OOD dataset)

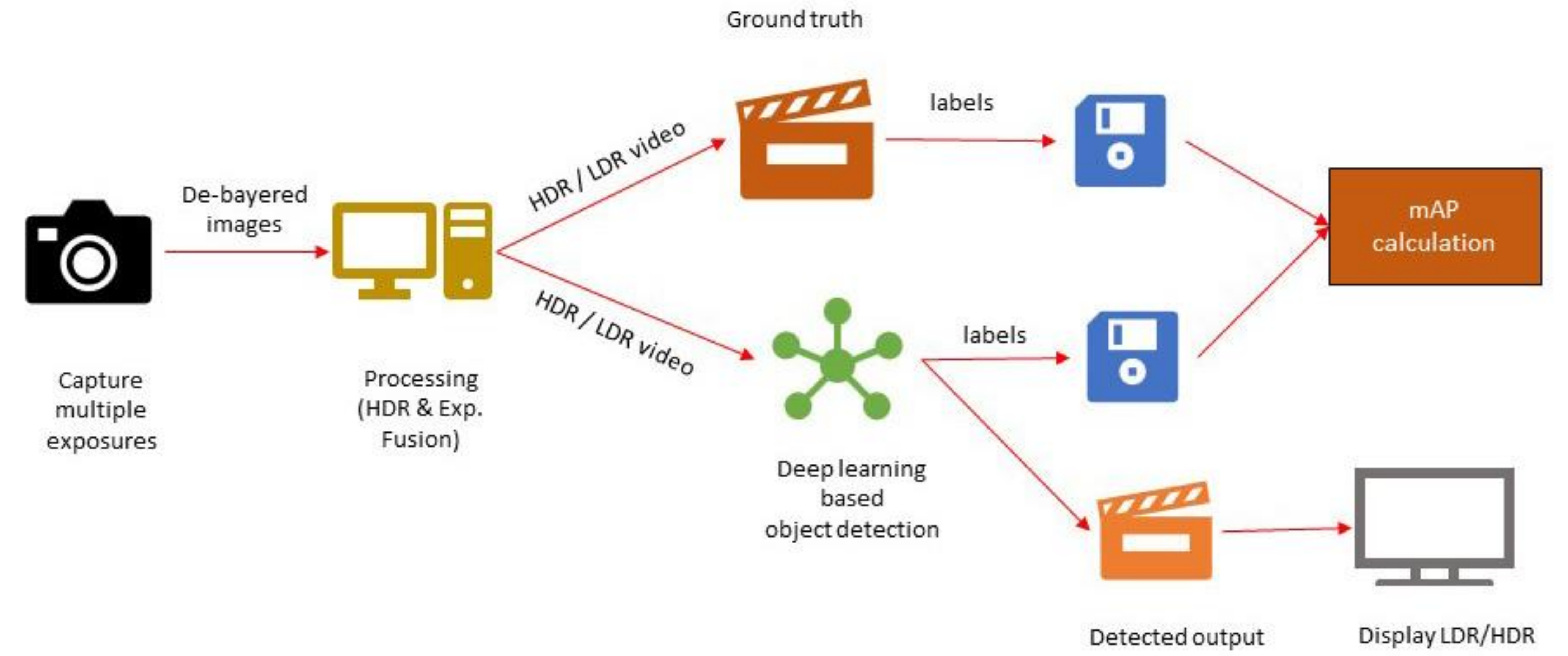
- 6 video sequences
  - Varied capture sources (Canon, ARRI, Spheron)
  - Average dynamic range 18 ± 2 stops.
  - Shortlisted images → $\mathrm{GT} \approx 1300$ images.
  - Annotated and cross-verified by 4 annotators.
  - Object categories: 6 object categories.
  - To test both approaches 1 and 2.



Later we shall highlight the key problems in annotating HDR images..

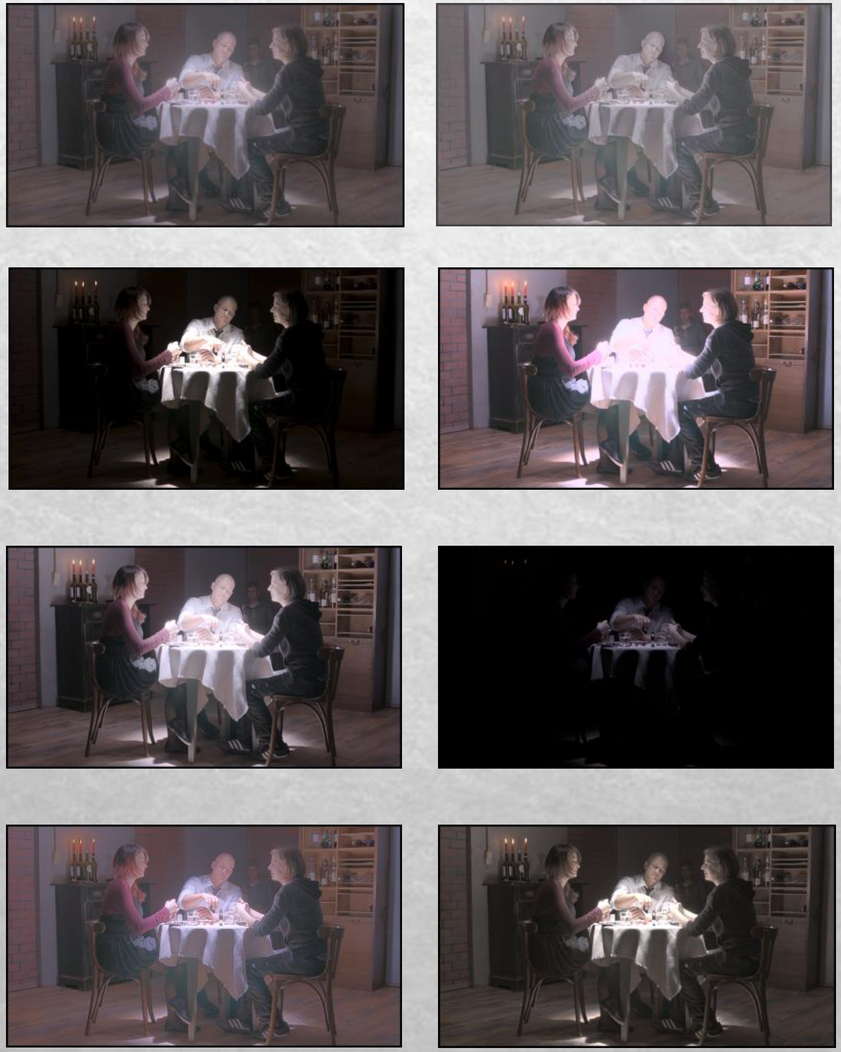
PART – II :
Setting up a detection pipeline

Designing a single HDR/LDR detection pipeline



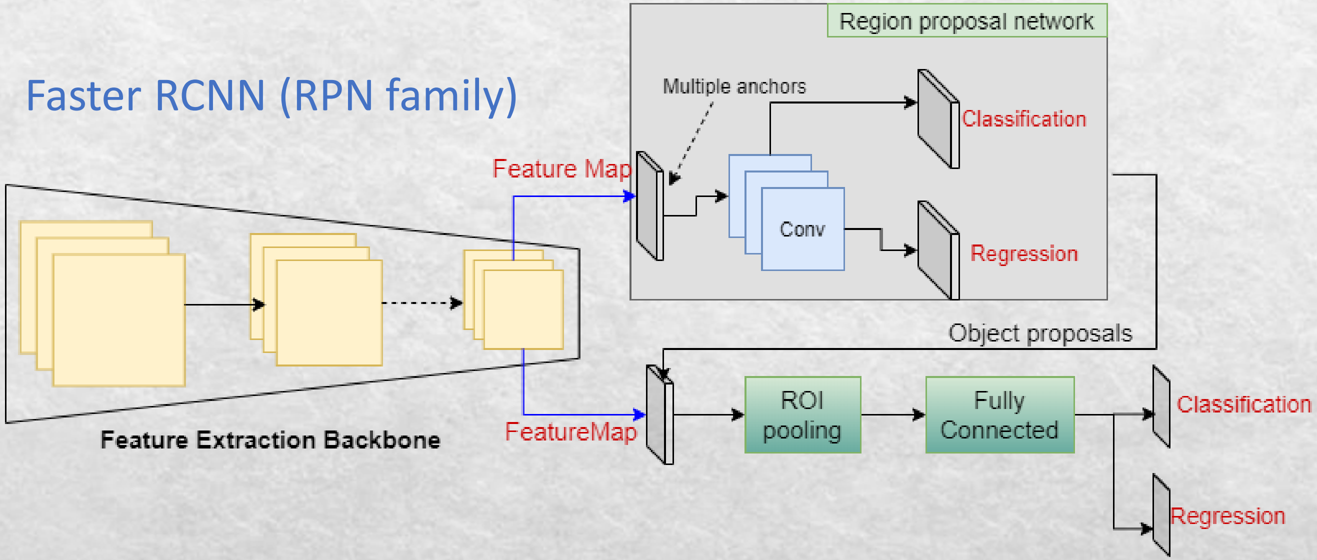
Pipeline works for both HDR & LDR videos

Materials

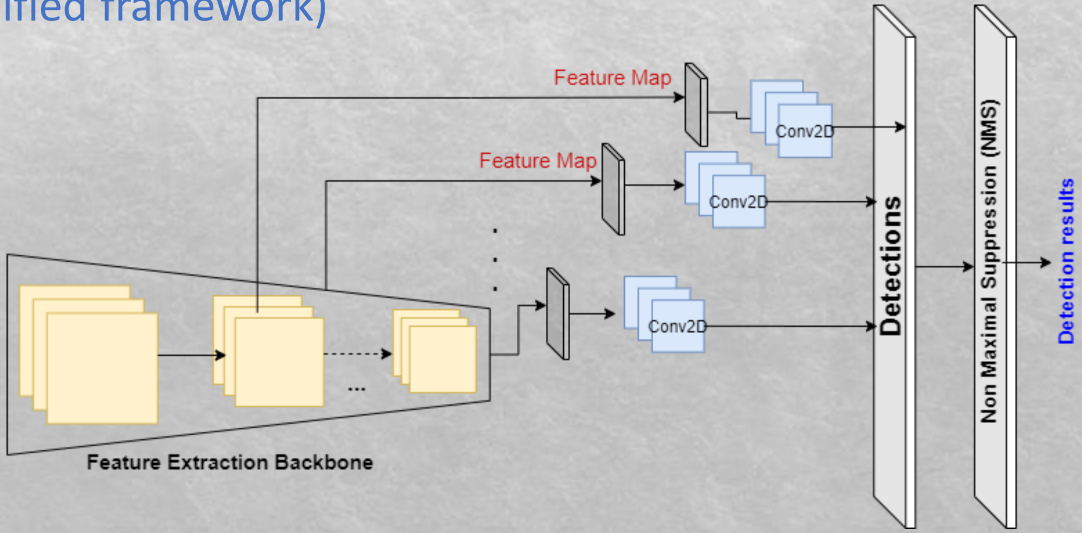


8 HDR to LDR mapping techniques

Faster RCNN (RPN family)

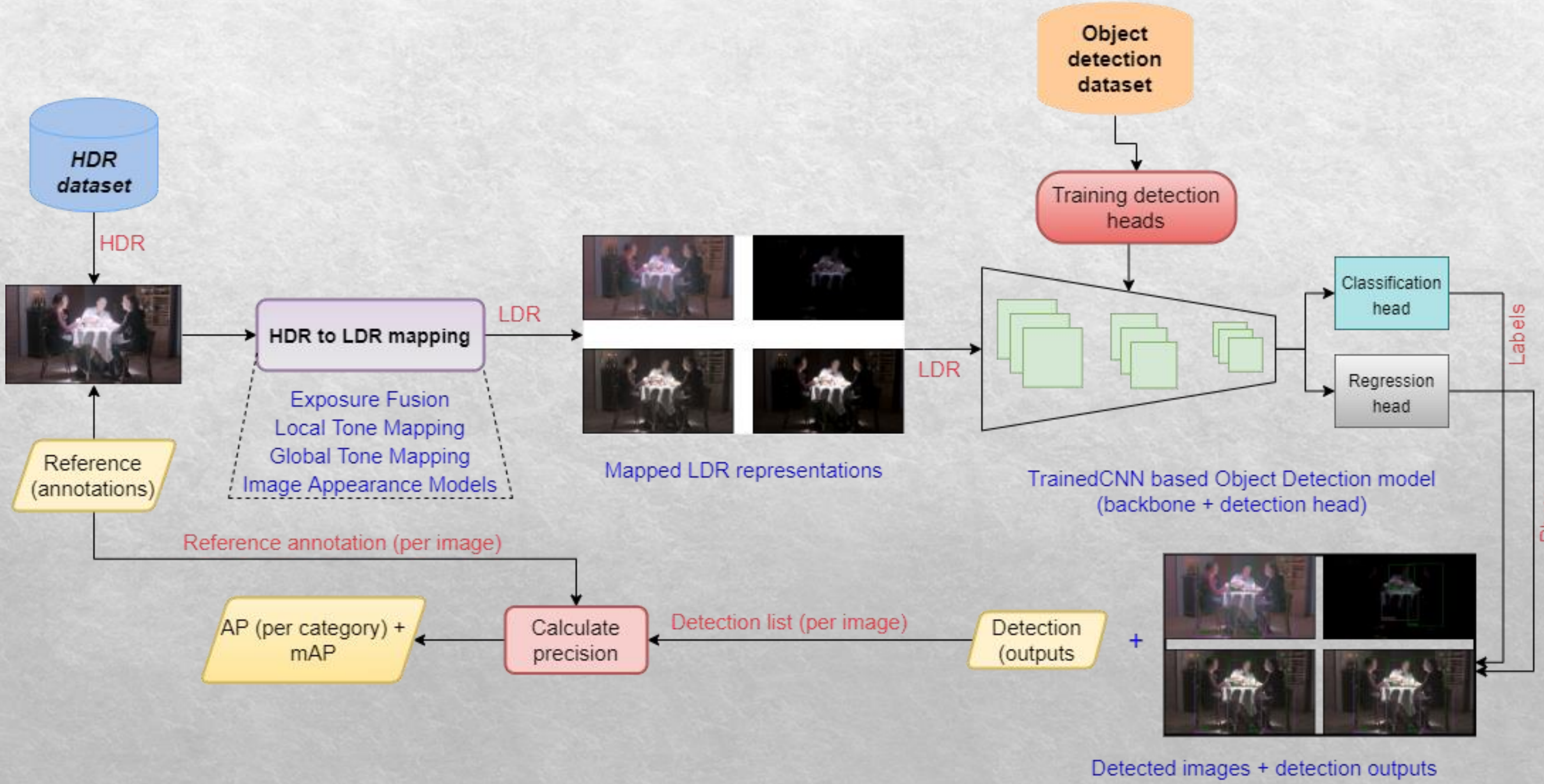


SSD (unified framework)



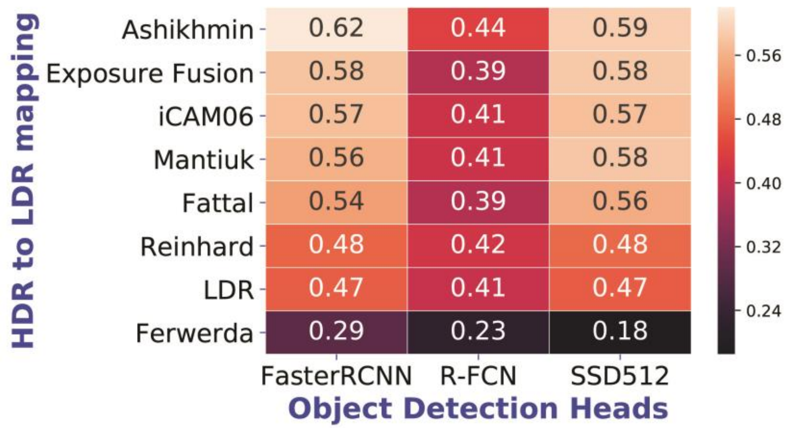
PART – III :
Backward compatible HDR object detection

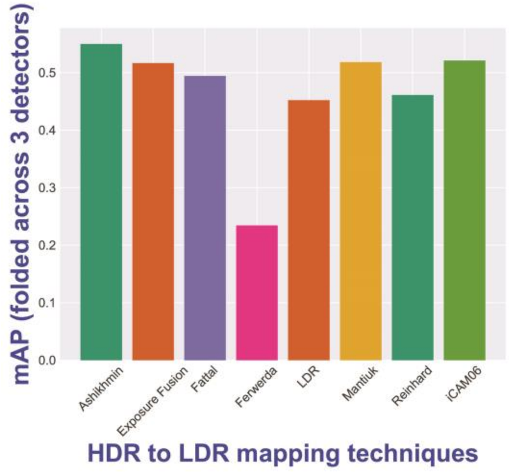
1. Backward compatible HDR object detection



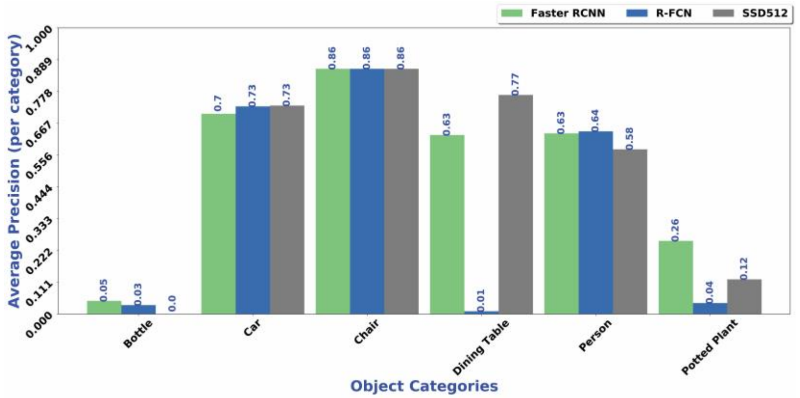
Evaluation and results

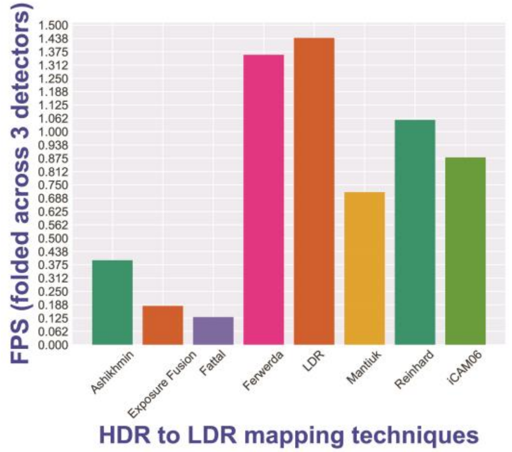
- 7 HDR to LDR mapping techniques (each representing a class of mapping techniques) + LDR image
- 3 object detectors (two RPN family and 1 unified framework)





- Faster RCNN & SSD 512 > R-FCN
- Most TMOs > LDR image
- Gradient based TMOs best and fastest
- Smaller objects difficult to detect





PART – IV :
HDR object detection

Key challenges & solutions for HDR object detection

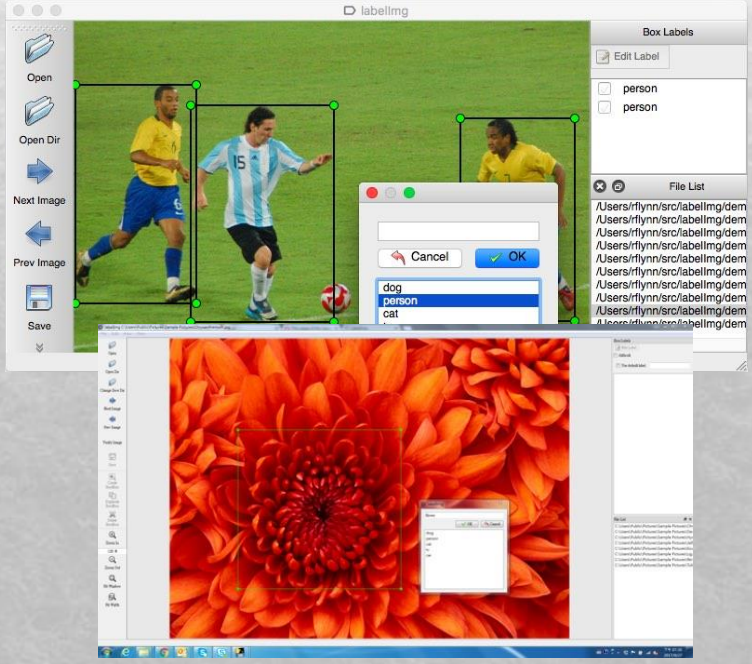
Challenges

- No HDR capture software / hardware has a complete pipeline
- No annotated HDR image / video dataset exists to date
- No annotation tool supports HDR images
- No object detector trained for HDR images to date.

HDR image/video content

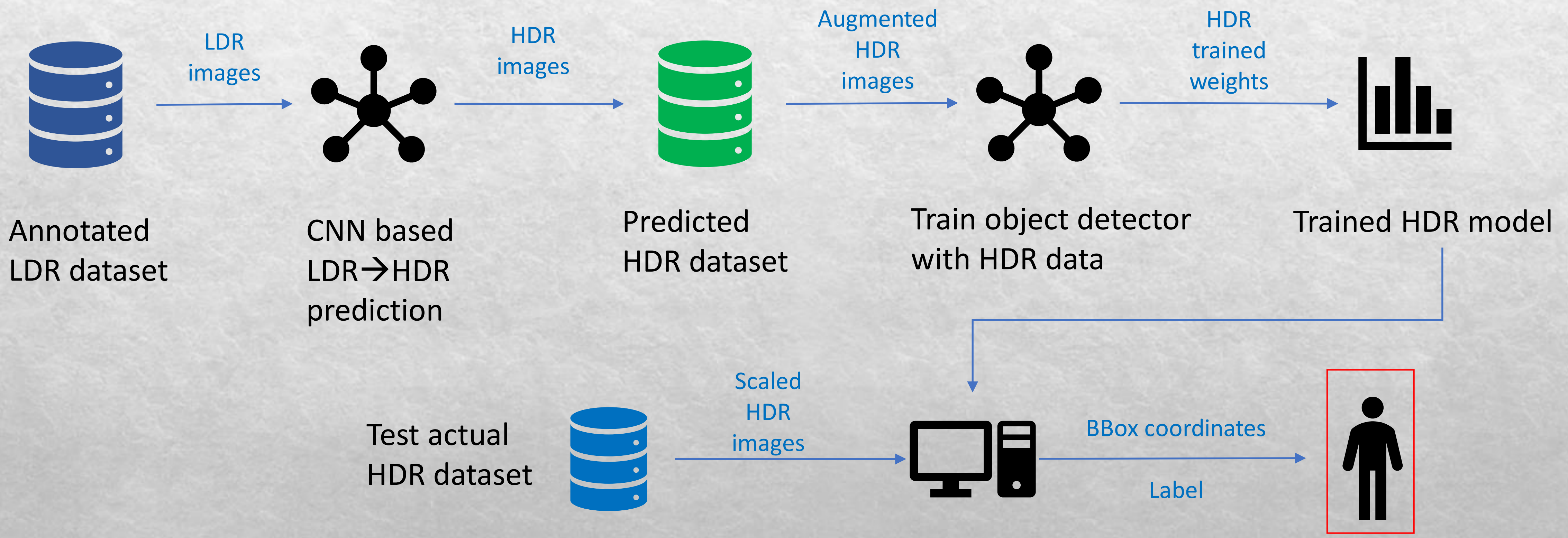
Solutions

- Use LDR image datasets to create pseudo-HDR datasets (already contains annotations)
- Explore LDR to HDR expansion techniques and evaluate them.
- Use pseudo-HDR datasets to train existing detectors with HDR augmentation
- Test and refine detector based on actual OOD dataset

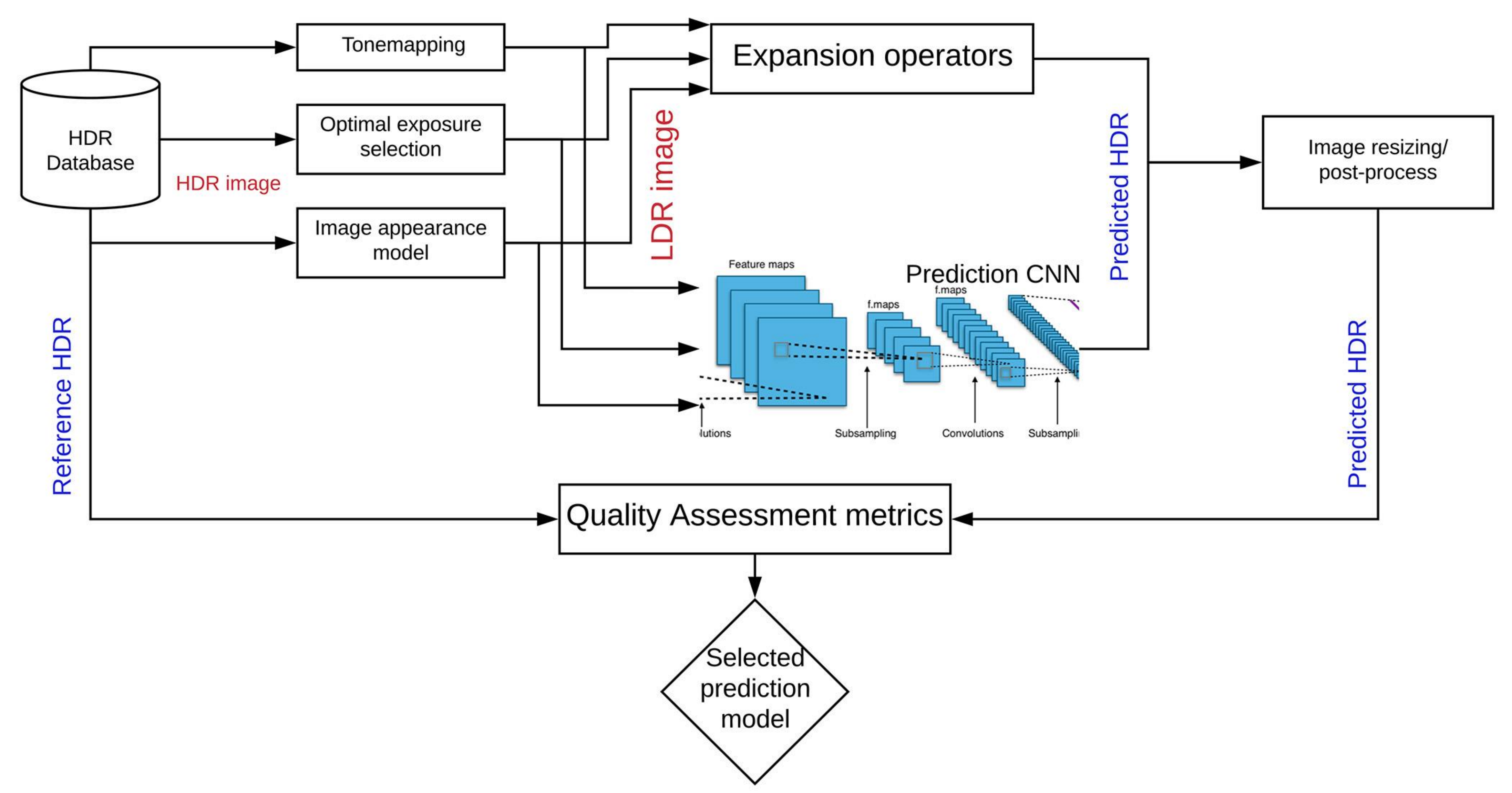


Annotation tool

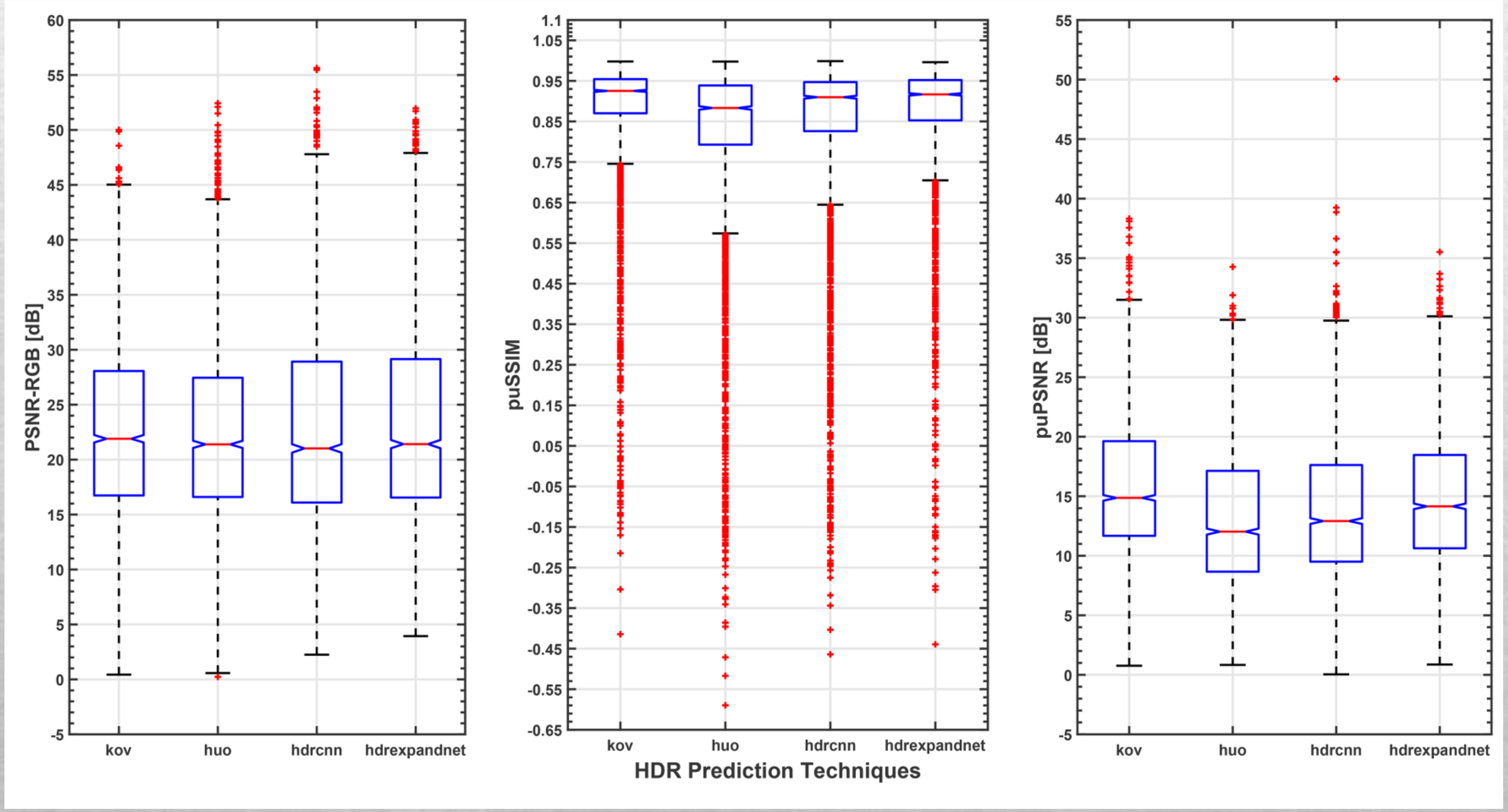
HDR object detection pipeline

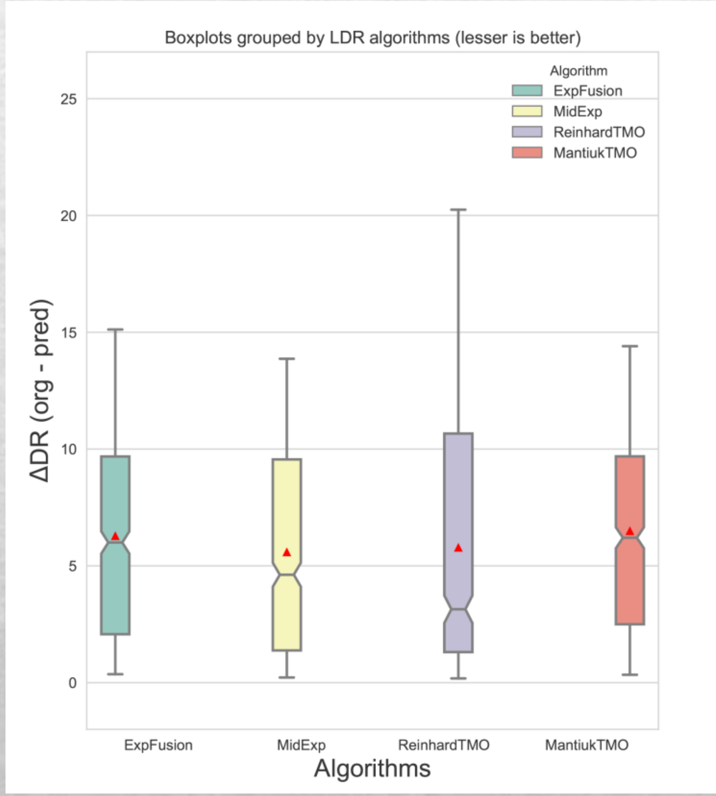


LDR expansion evaluation pipeline



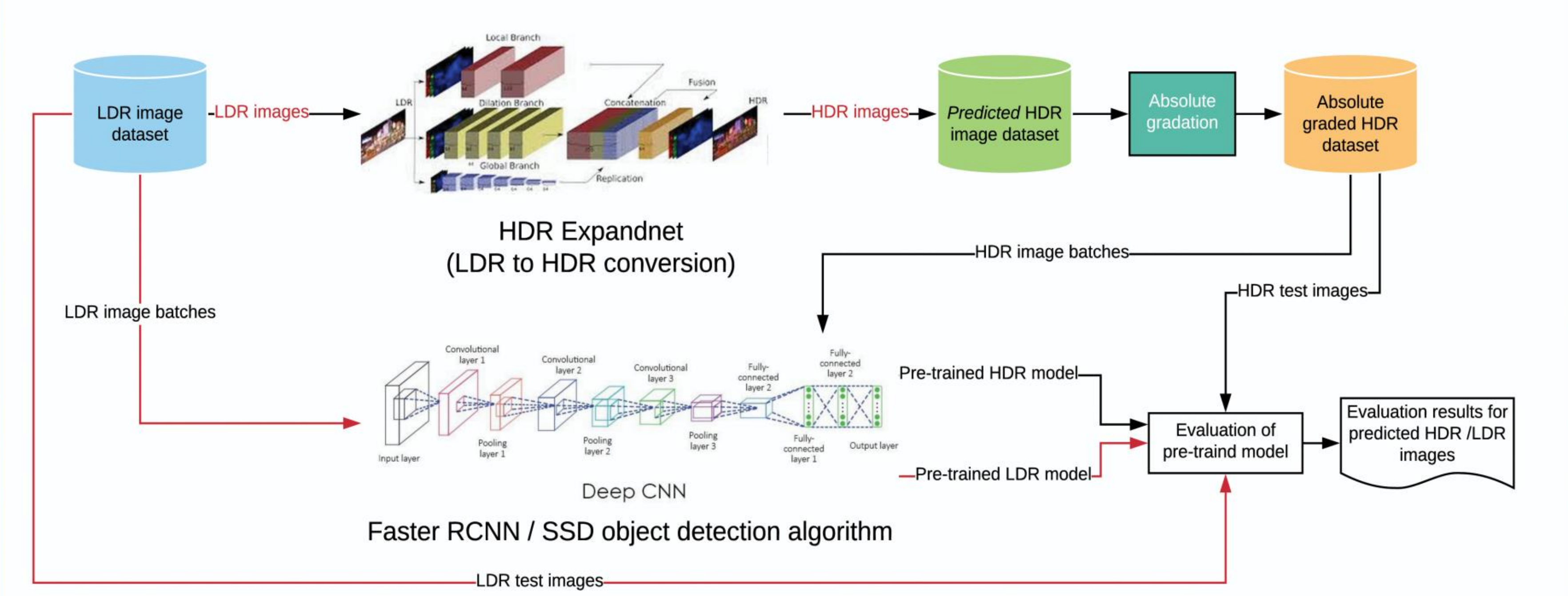
Expansion evaluation results…



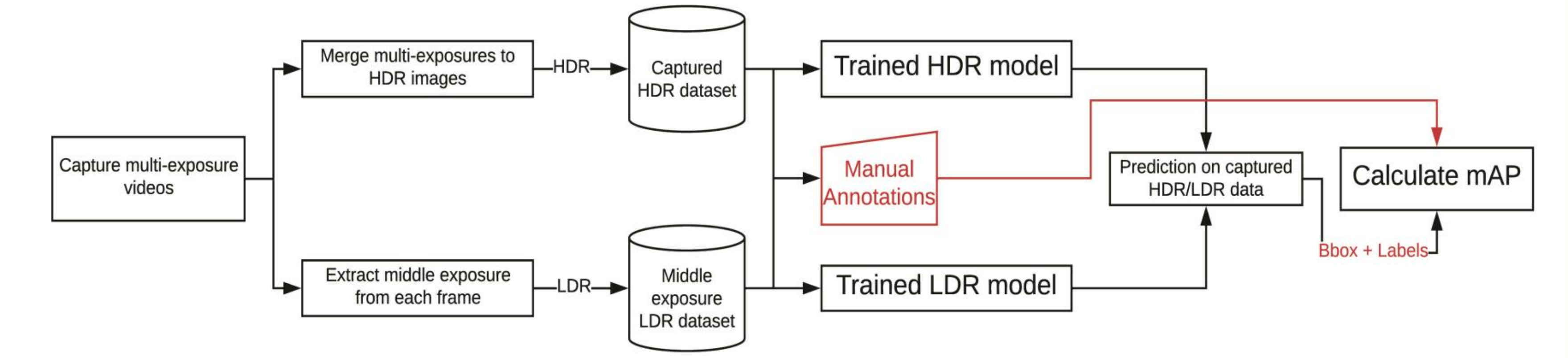


HDR object detection

- Dataset selected:
  - PASCAL VOC (small)
  - Contains 20K images
  - 52K annotations
- LDR2HDR:
  - Deep learning based HDR expandnet
- Object detectors:
  - Faster RCNN
  - SSD
- Test dataset:
  - OOD dataset 1289 images

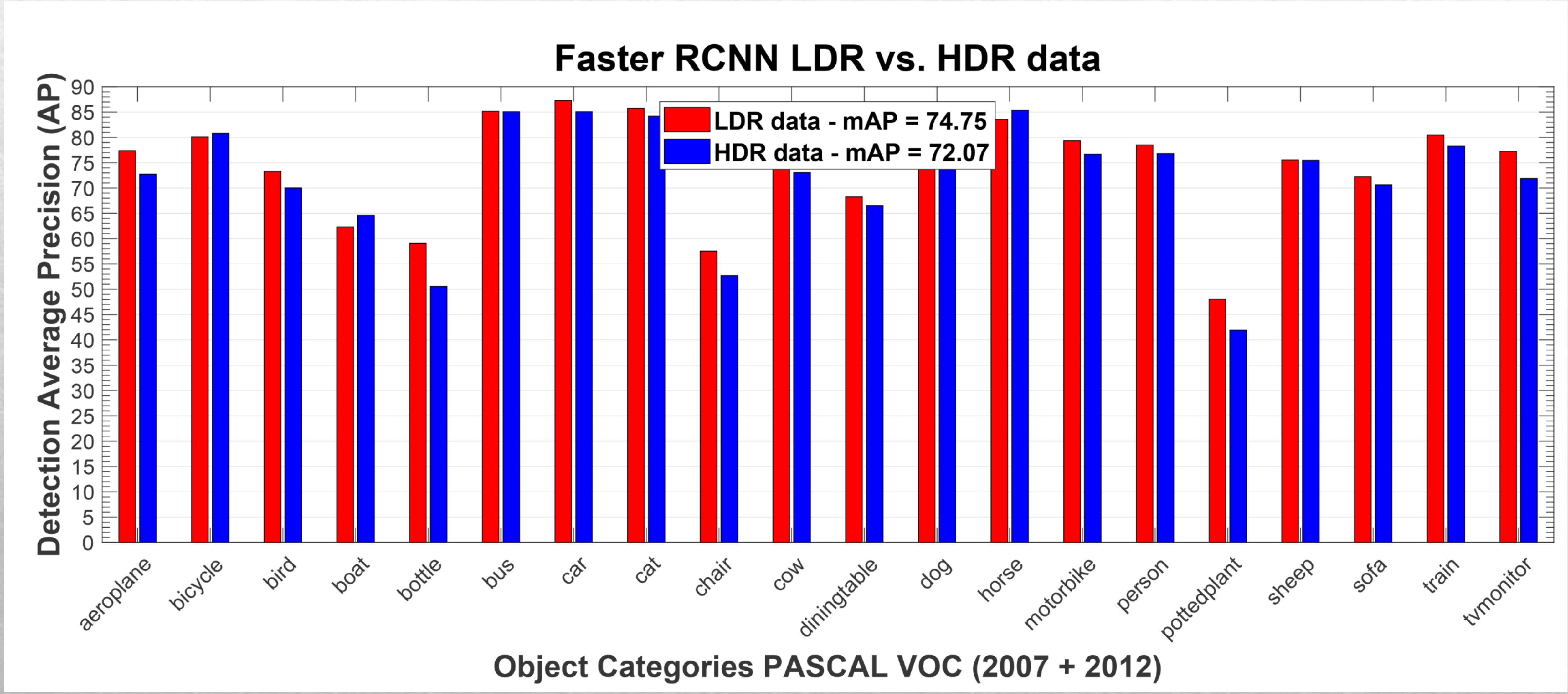


PART A - Training and evaluation of LDR and predicted HDR models

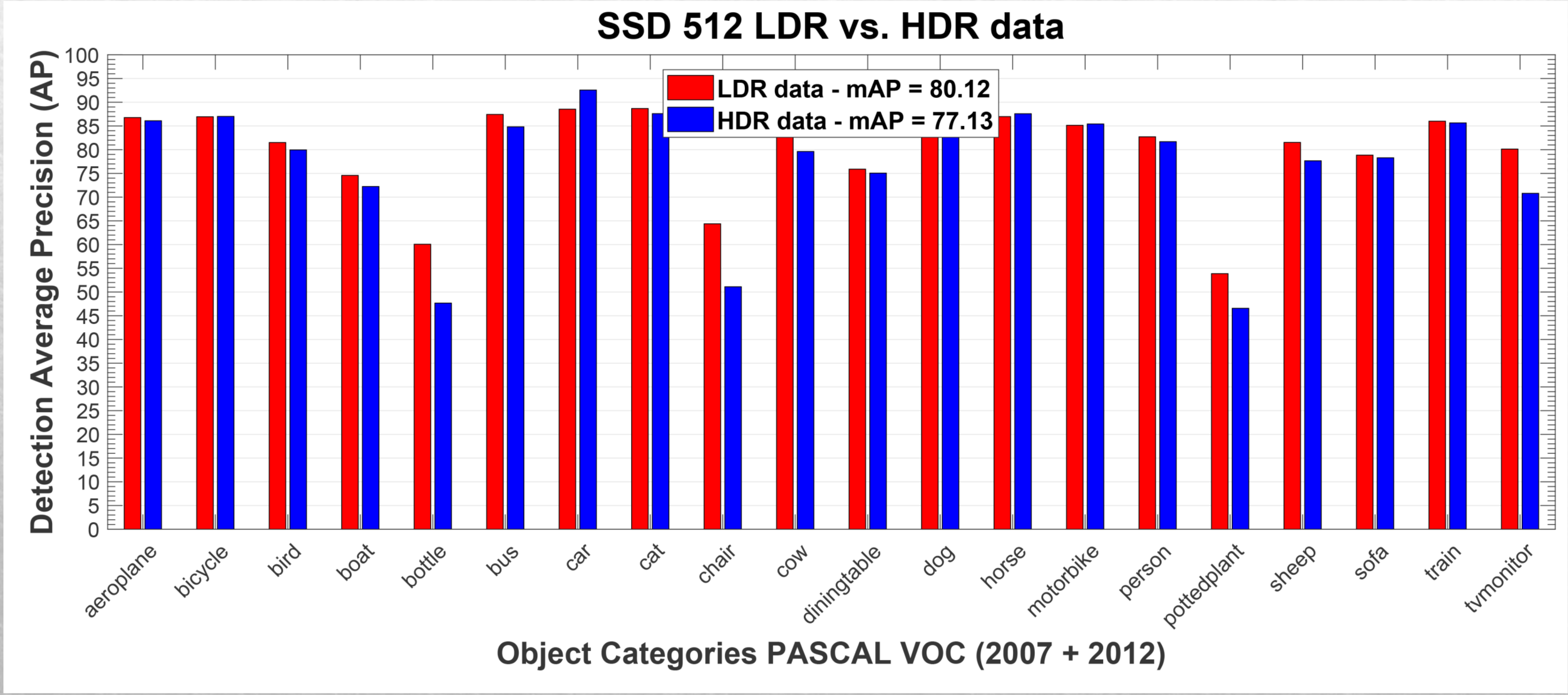


PART B- Evaluation of HDR and LDR trained models on HDR and Middle Exposure LDR out-of-distribution captured HDR dataset

PASCAL VOC test (in distribution) – Faster RCNN

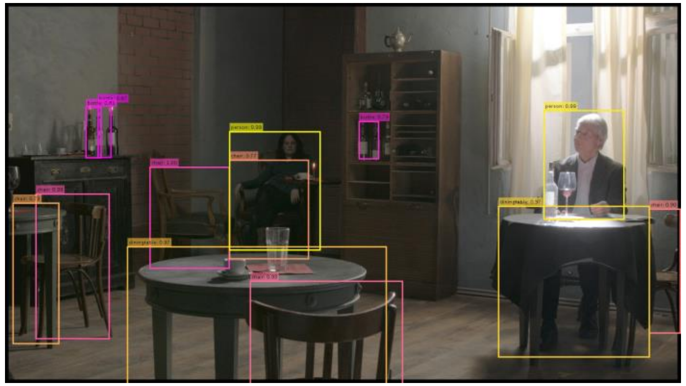
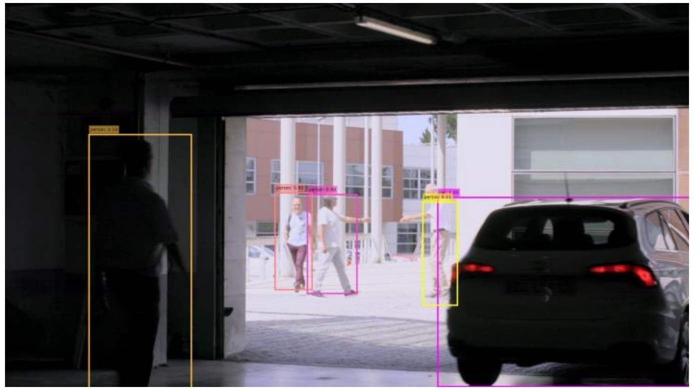


PASCAL VOC test – SSD 512



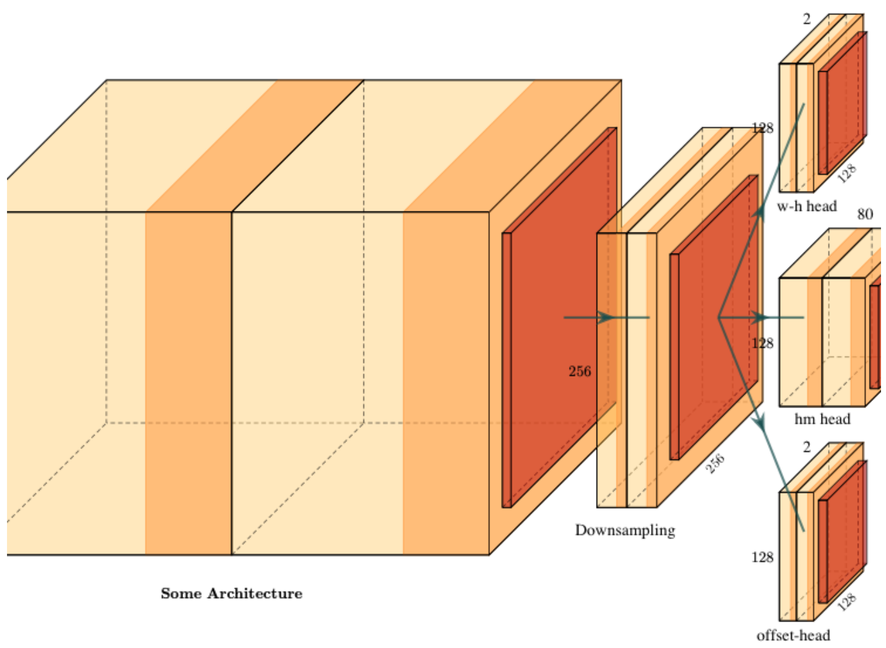


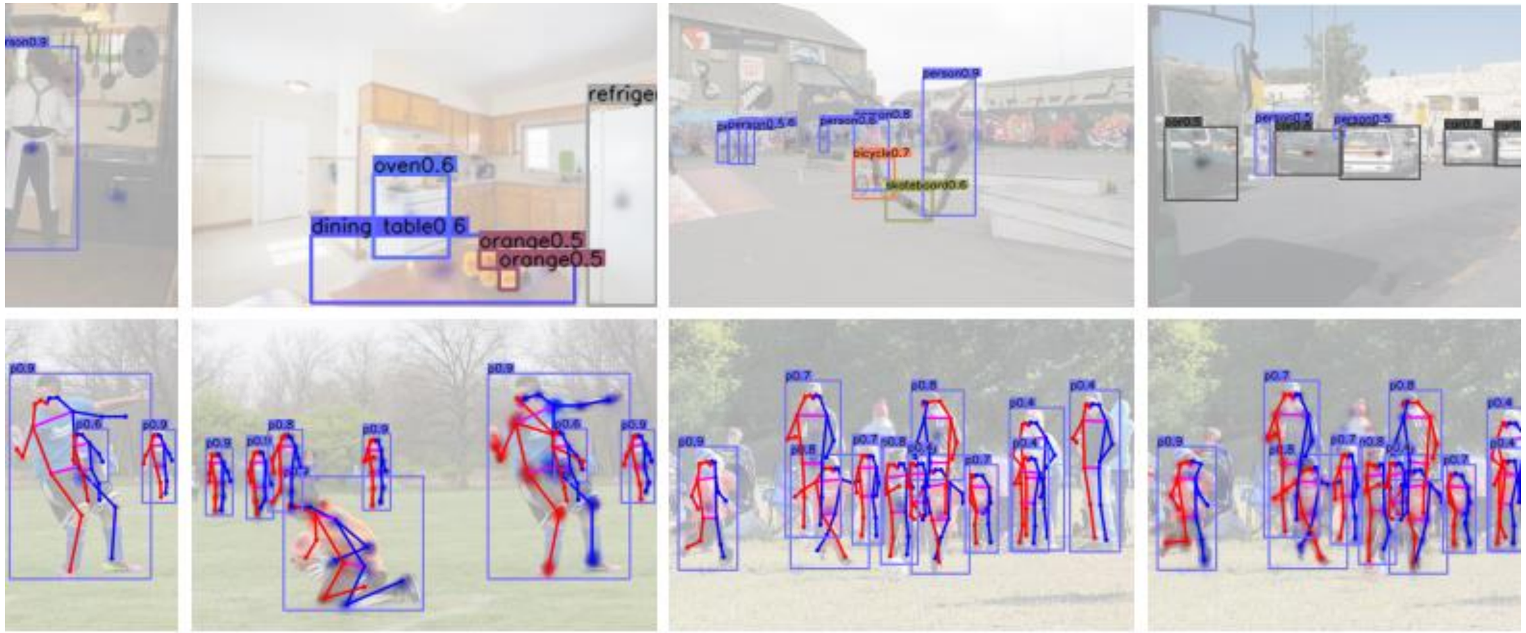


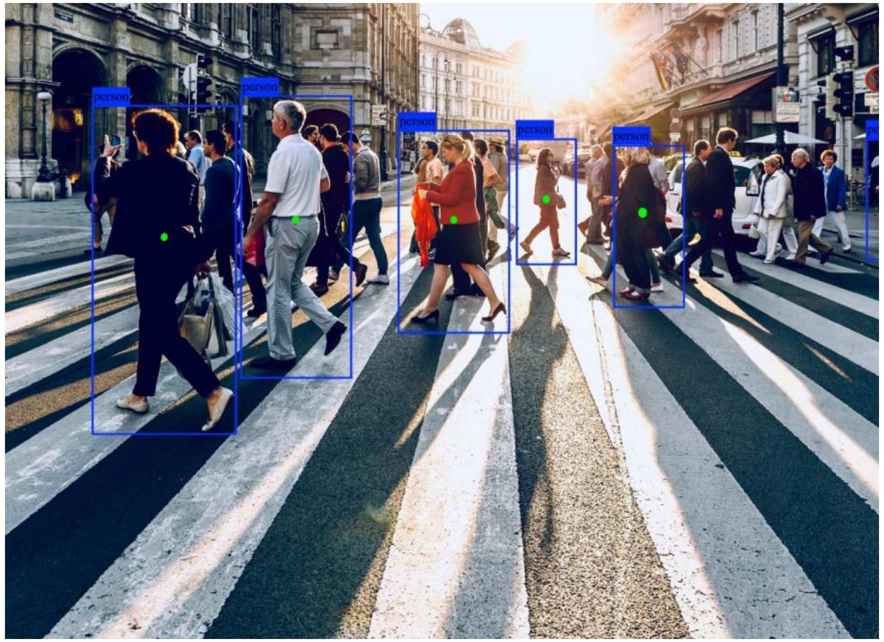



- results HDR vs LDR evaluation

PART – V :
The future…

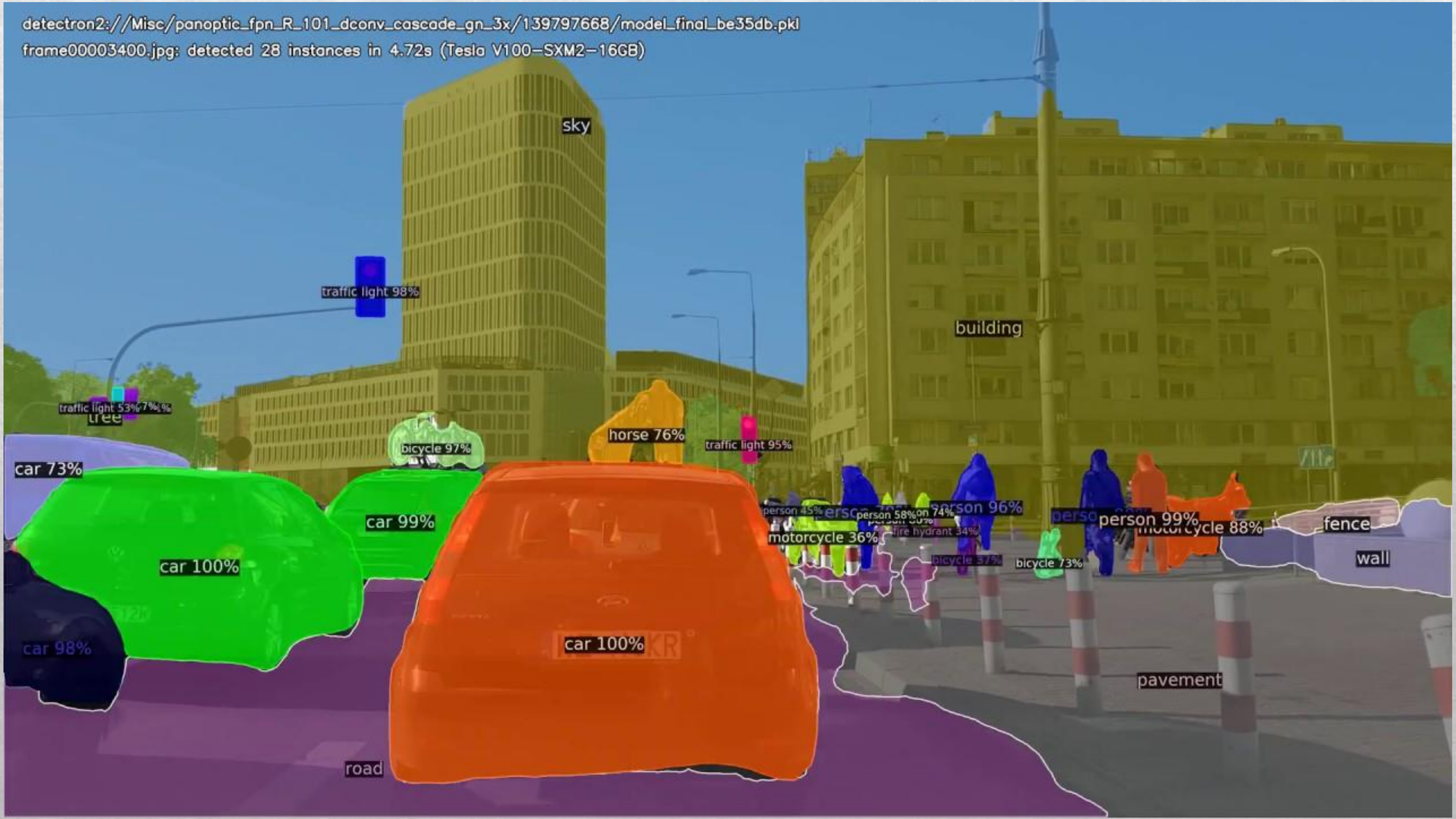






Keypoint estimation

Real time scene understanding – panoptic segmentation



thank you..