Optimizing Camera Image Quality to Maximize Computer Vision Results

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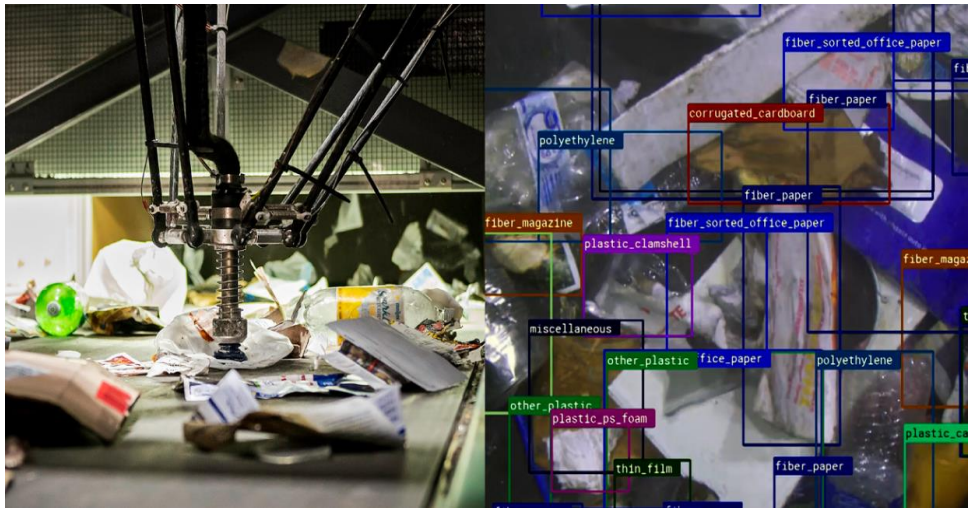
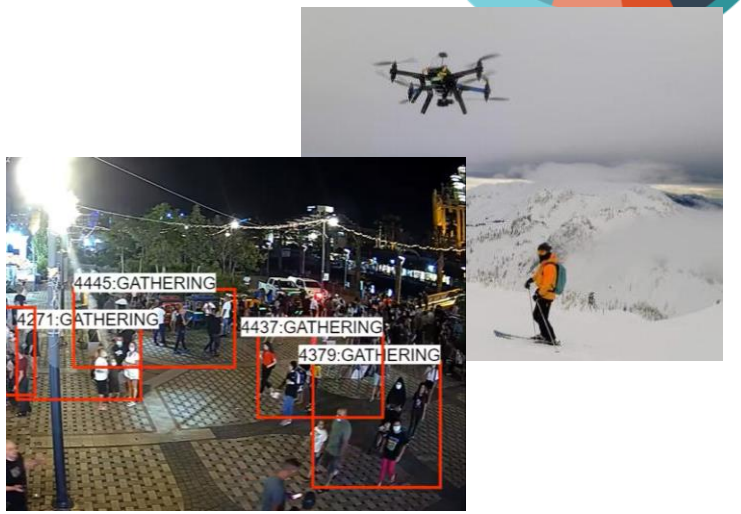
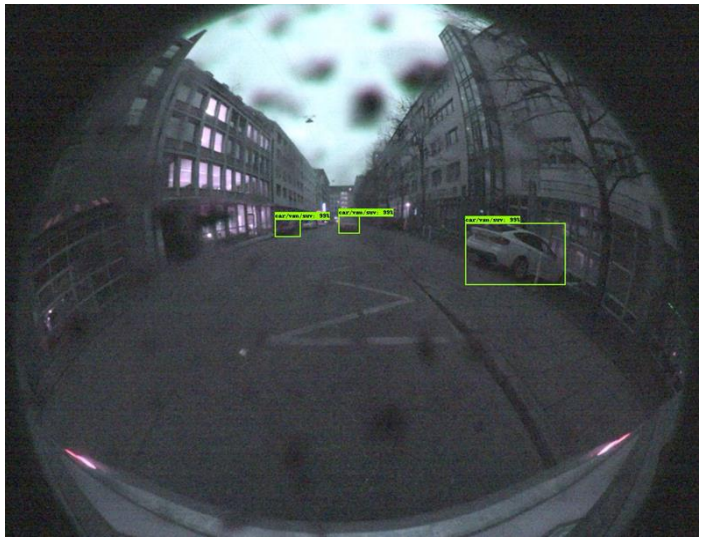
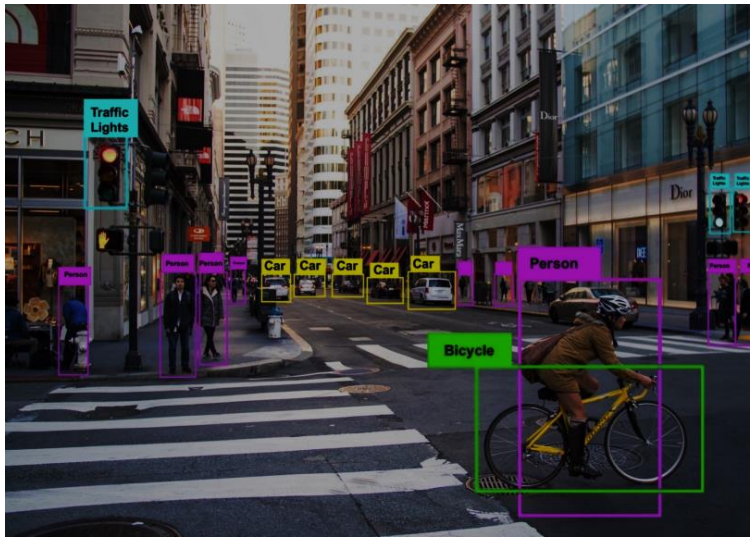
Unlimited Number of Computer Vision Applications!

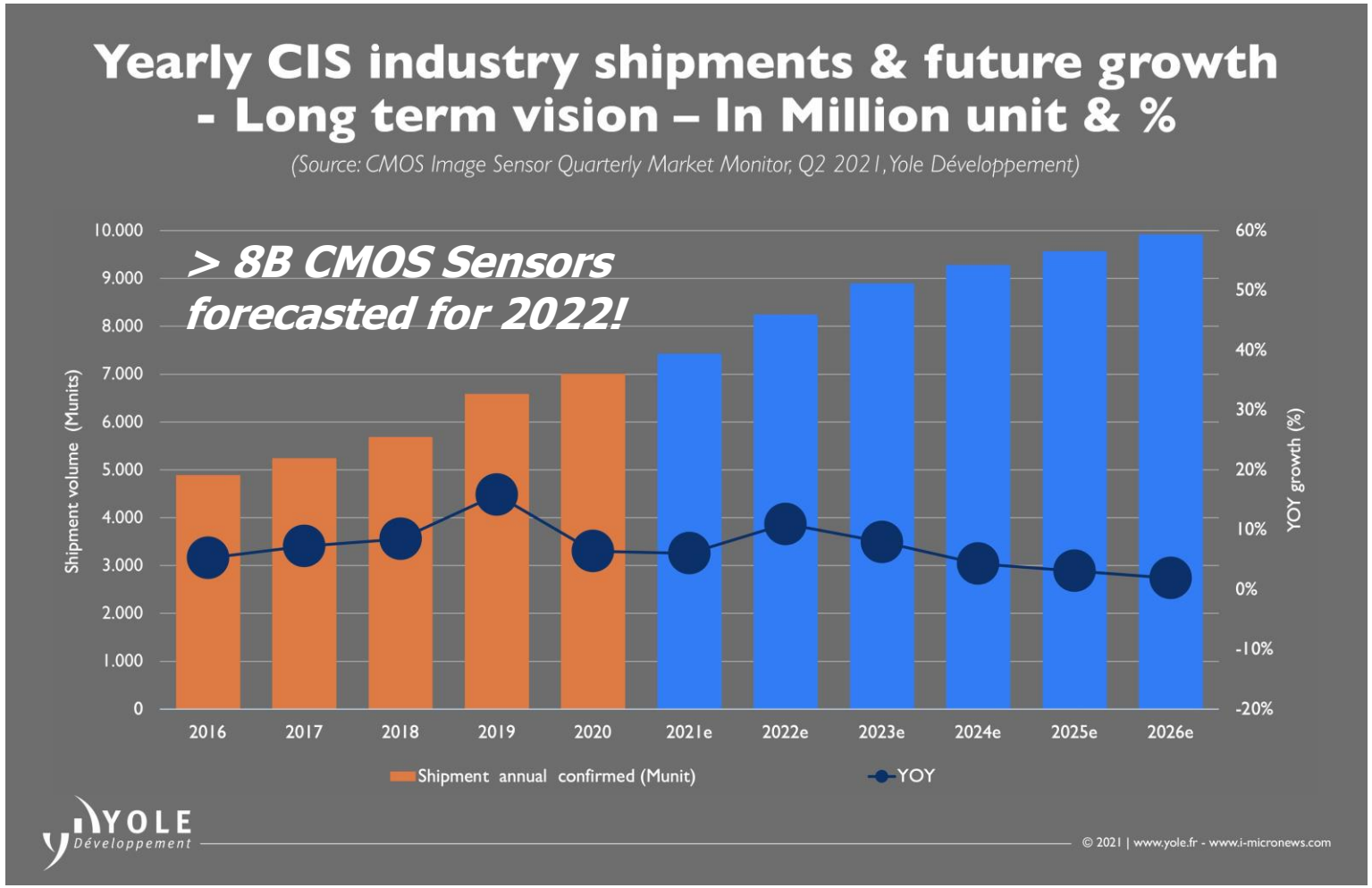








Driven by a Massive Quantity of Image Sensors



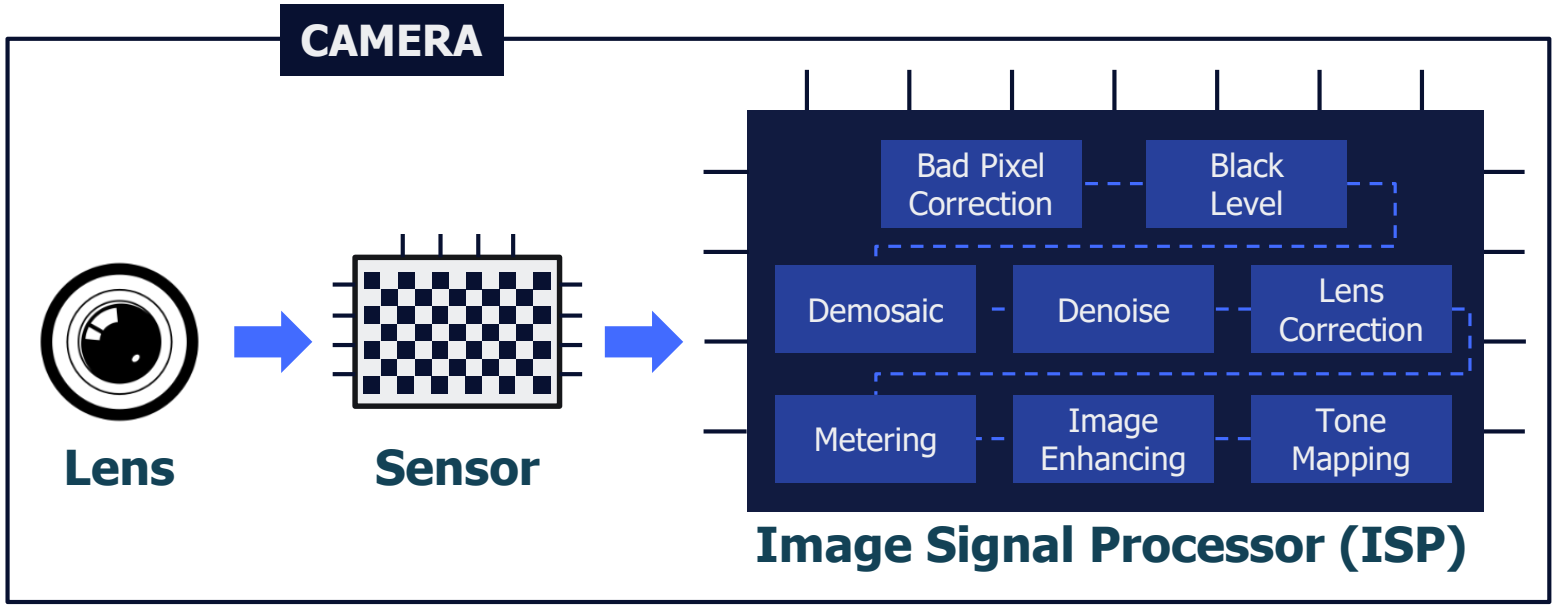
… and democratization of computer vision development

But… What Problems Impact Vision Accuracy?

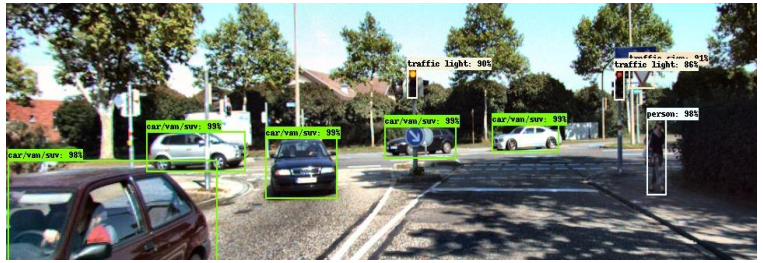
- Low / high light and bad weather
- Dynamic effects (motion blur…)
- Poorly tuned image signal processor (ISP)
- Annotation errors or training dataset quality
- Training datasets from different sensor modules
- …

Cost of failure gets very large for safety-critical applications

Typical Camera System



Display



Computer Vision Models

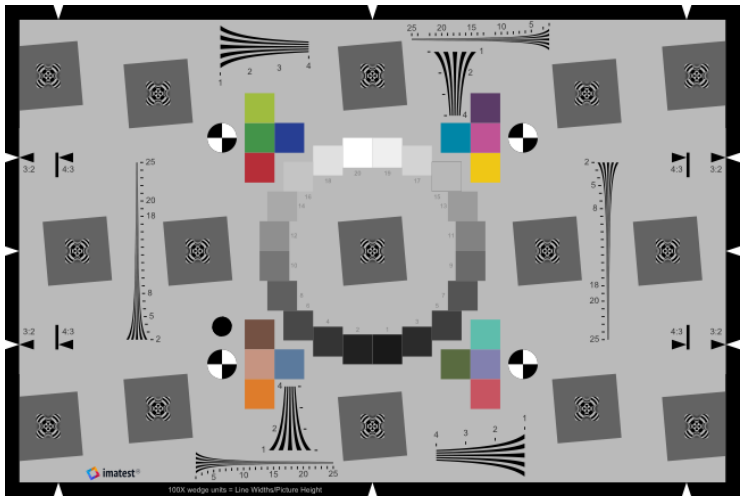
Lens parameters

Sensor parameters

ISP parameters

Massive parameter space controls the image quality for each camera configuration

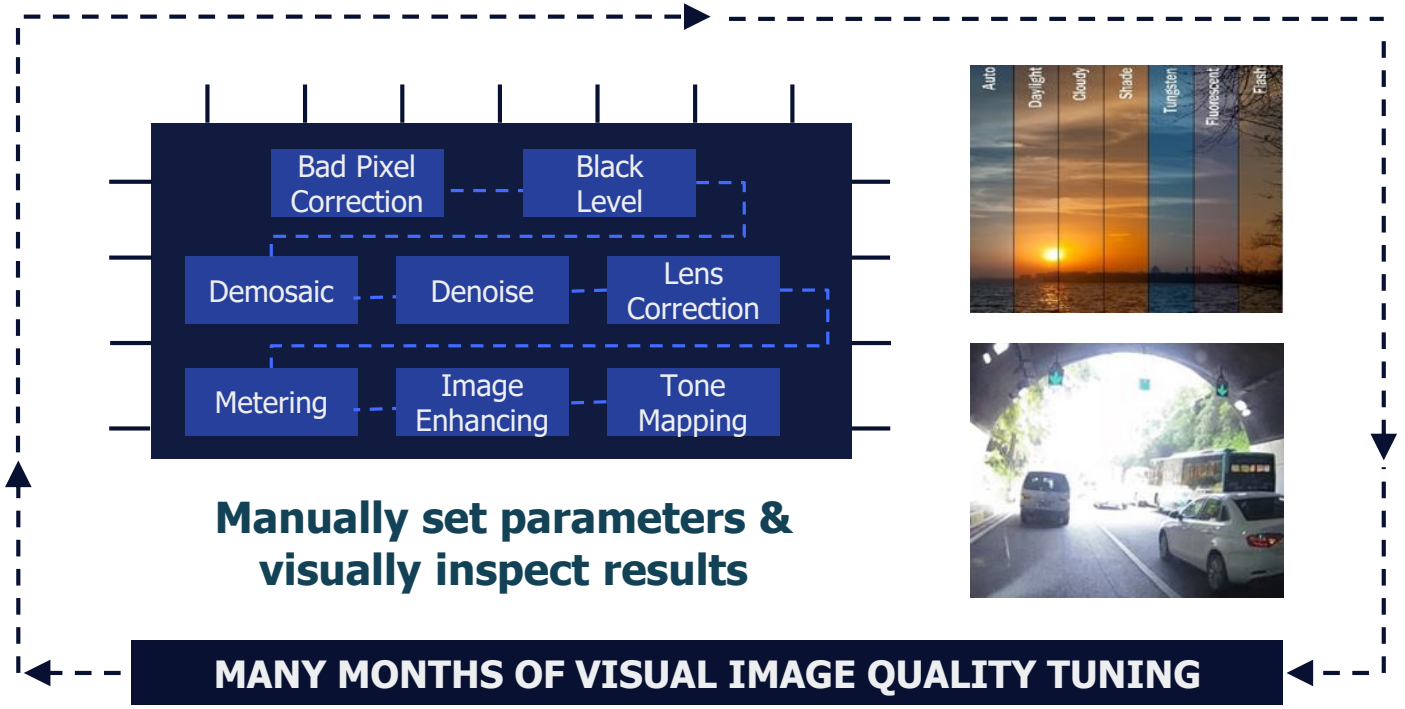
Today's Manual ISP Image Quality Tuning Process



- Imaging lab setup
- ISP tuning tools setup
- Camera module calibration
- Initial setting, e.g. gamma, CCM, WB
- Iterate > AE / brightness, LTM, Contrast (gamma)
- Refine CCM / saturation
- Demosaic
- Iterate > Denoiser, sharpen
- Objective / subjective evaluation

DONE usually means "Good enough"

Challenges with Today's Manual ISP Tuning



Resource-intensive
Too much cost & time

Inefficient
It doesn't scale to my projects

Uncertain
"Good enough?"
"How do I know?"

Limited – Manual ISP tuning is "**NOT** effective for computer vision"

European Tier 1 Camera Team

Replacing Manual ISP Tuning with Automated Optimization

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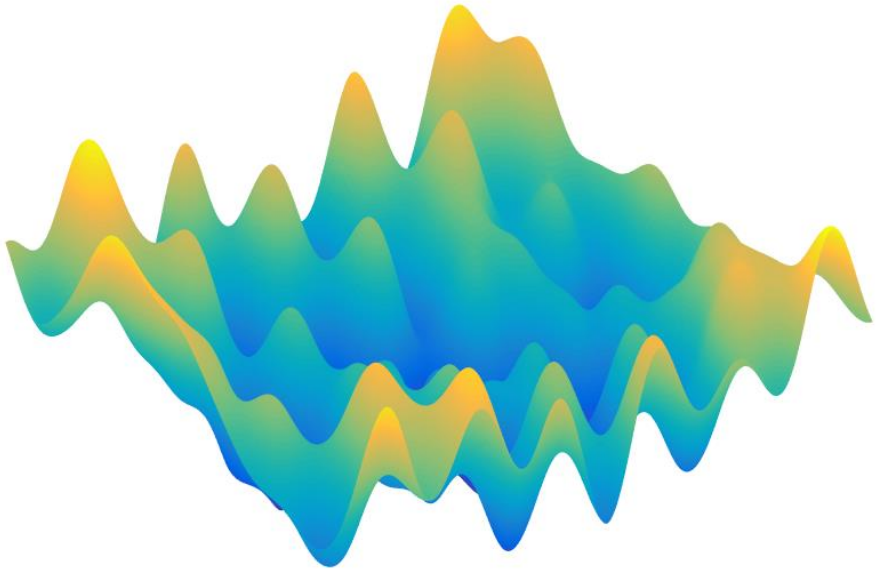
But Aren't There Already Lots of Automation Tools?

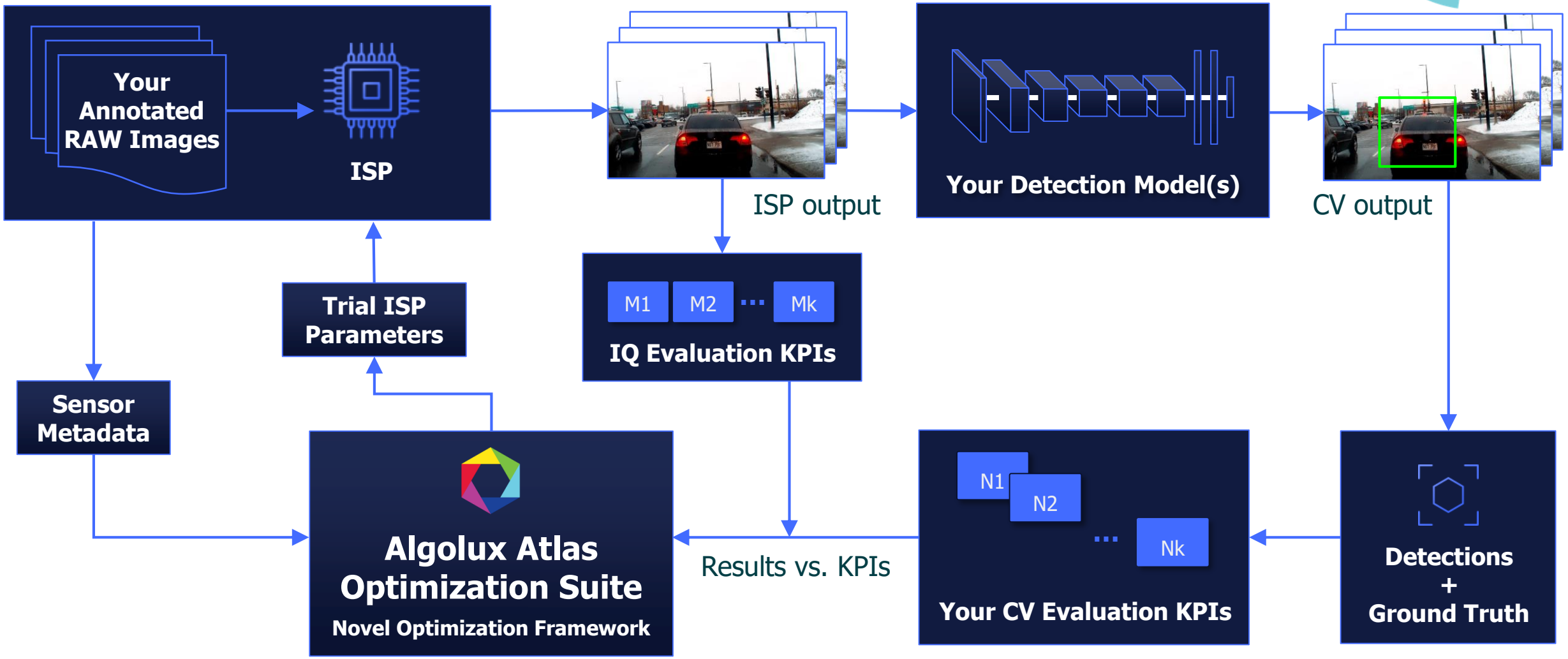


NO!

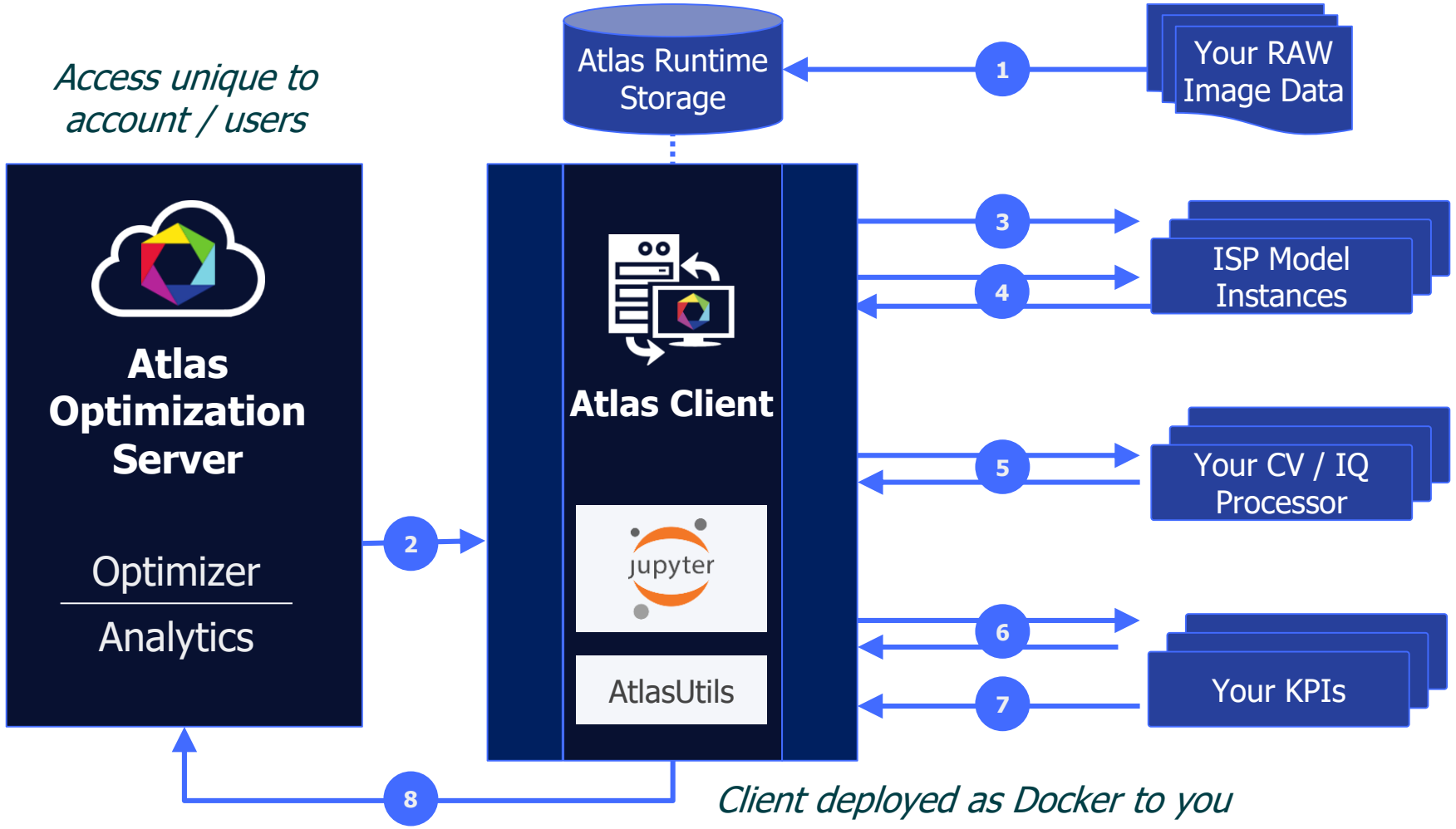
- Large number of parameters
- Highly non-convex ISP parameter space
- Multi-objective process for tuning
- Conflicting goals (e.g. sharpness vs. noise)
- Limited ISP tuning automation

Today's tools and workflows don't address this PAINFUL need

Atlas Workflow for Image Quality and Computer Vision



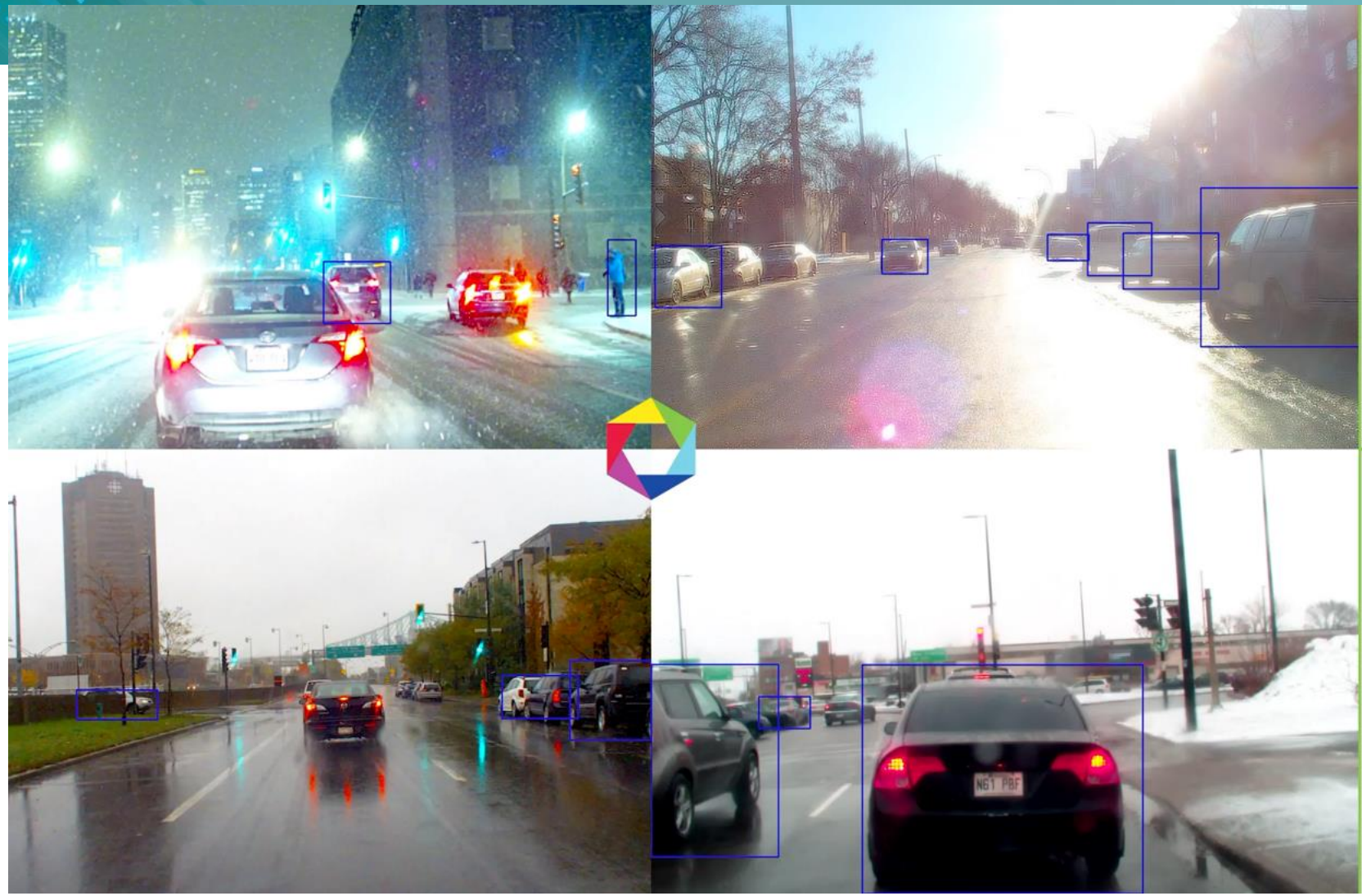
Atlas Deployment and Workflow Operations

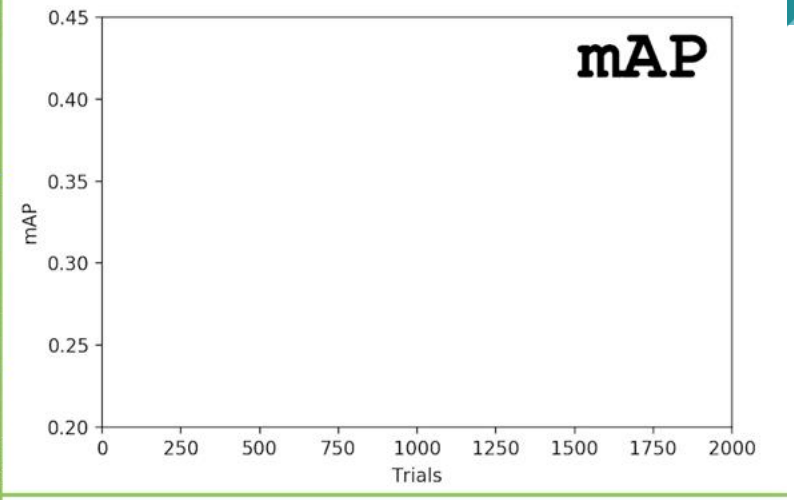


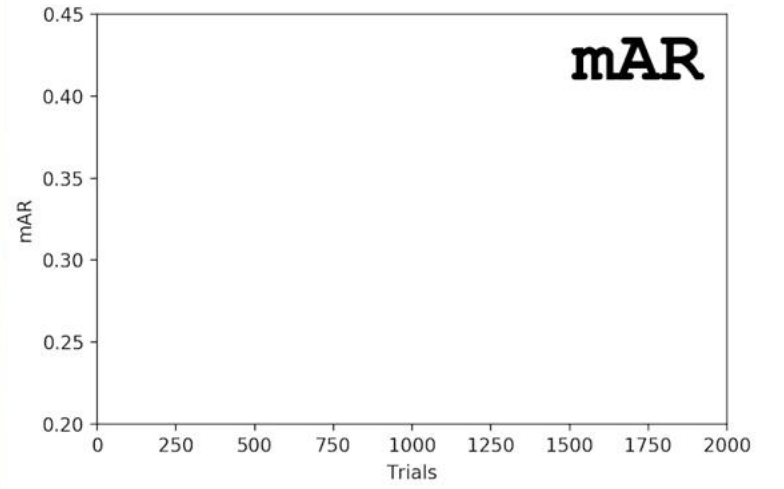
Workflow:

1. Add RAW images to the Atlas Runtime Storage
2. Get ISP Parameters from Atlas Optimization Server
3. Set ISP Parameters
4. Process RAW Data with ISP Model Instances
5. Process ISP Output with CV/IQ Processors (e.g. CV algorithm)
6. Process CV/IQ Processor output with KPIs
7. Get KPI values
8. Send KPI values to Atlas Optimizer Server
9. Iterate

Atlas Automated Optimization for Computer Vision







Watch on YouTube

Atlas Case Studies

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Case Study 1

Evaluate Atlas ISP Optimization Across Different Computer Vision Models

Vision System	Configuration
ISP	**Renesas V3H**: 29 parameters optimized to maximize mAP for a range of sensor gains
Sensor	**ON Semi AR0231** | 2.3M pixels CMOS | RGGB
CV Model 1	**YOLOv3 Object Detector** • Classes: Car, Pedestrian, Traffic Light • Training dataset: COCO
CV Model 2	**FR-CNN Resnet-101 Object Detector** • Classes: Car, Pedestrian • Training dataset: KITTI
CV Model 3	**FR-CNN Resnet-51 Object Detector** • Classes: Car, Pedestrian, Bike, Truck, Traffic Light, Traffic Sign • Training dataset: Proprietary

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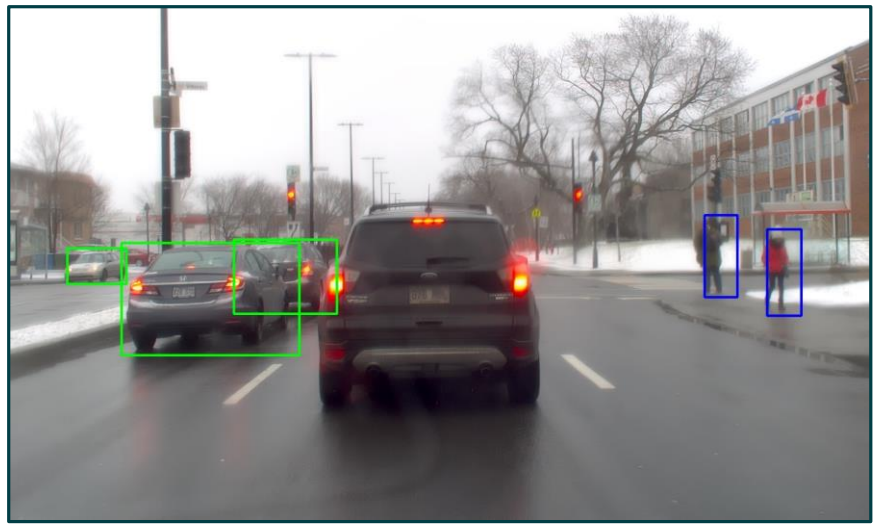
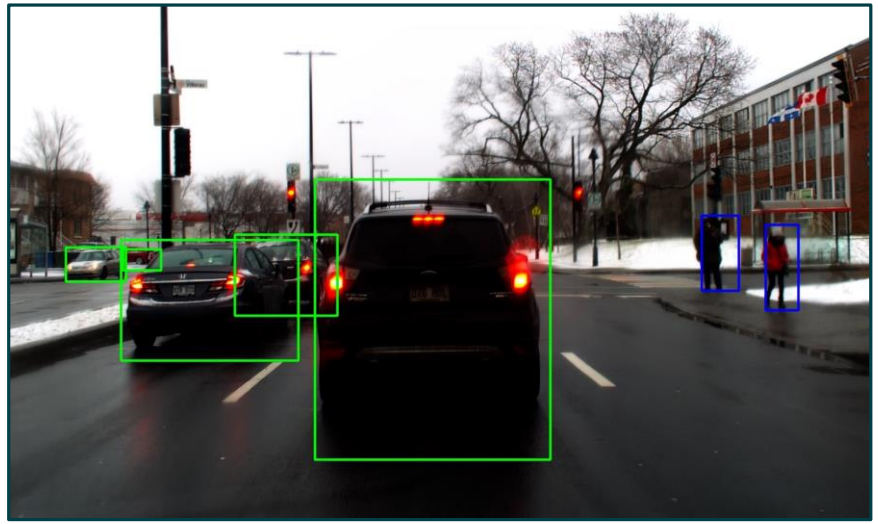
Case Study 1

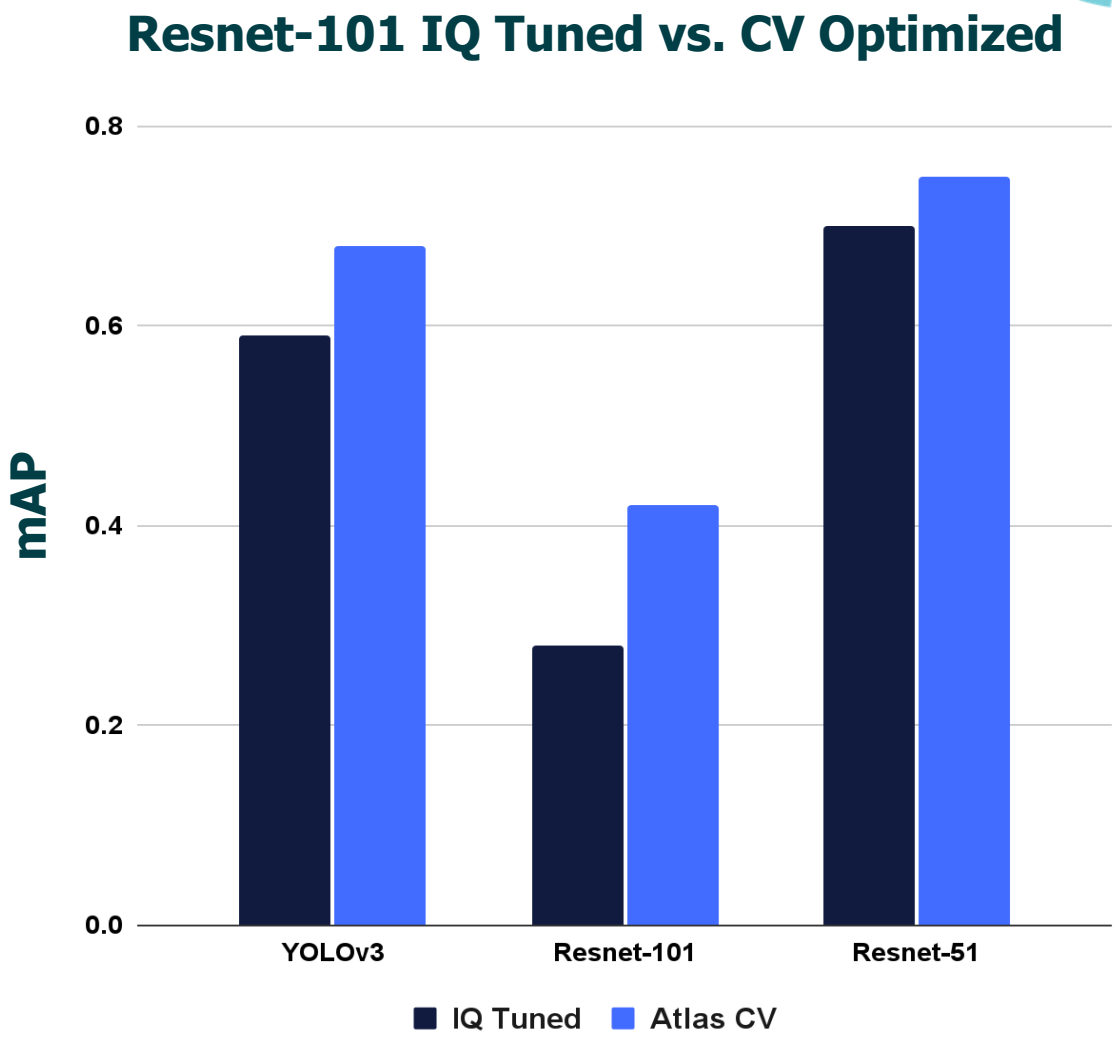
Optimization Results: Improved Precision



Before



After



Case Study 1

Different Detectors → Different ISP Configs

Case Study 2

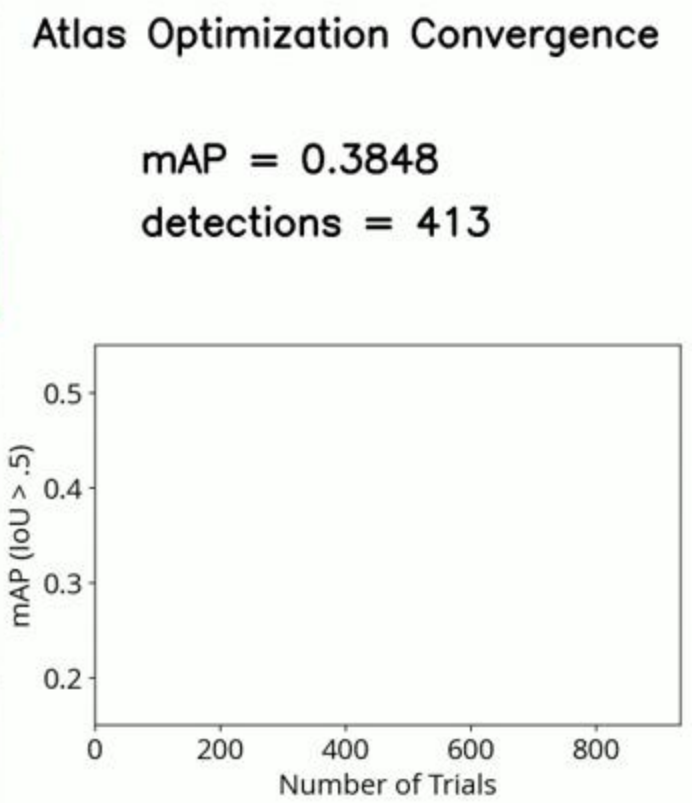
Optimize TDA4 Front-facing Vision System to Improve Object Detection Results

TDA4 ISP optimized to maximize mAP for a pre-trained YOLOv4 model

Vision System	Configuration
ISP	**TI TDA4VM**: 30 parameters optimized to maximize mAP for a range of sensor gains
Sensor	**Sony IMX490** | 5.40M pixels CMOS | RGGB
CV Model 1	**YOLOv4 Object Detector** • Classes: Car, Pedestrian • Training dataset: Proprietary

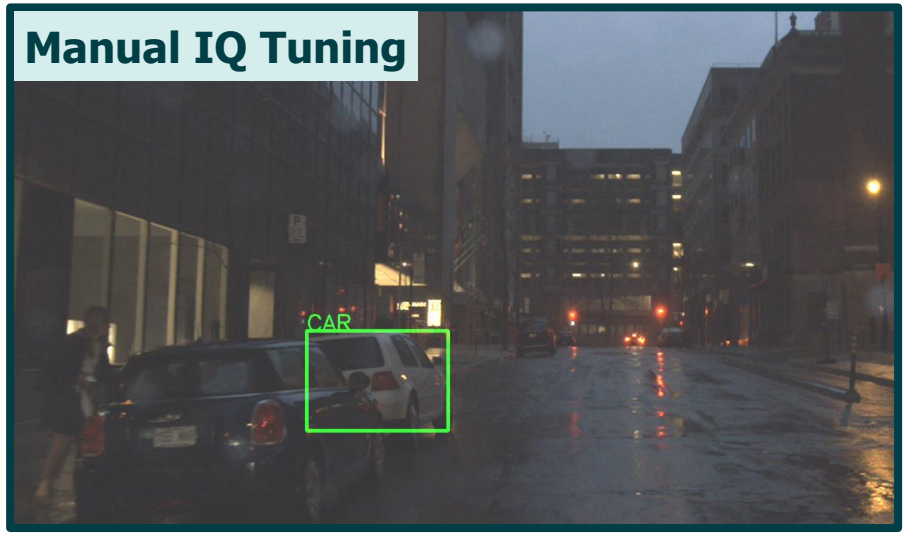
Case Study 2

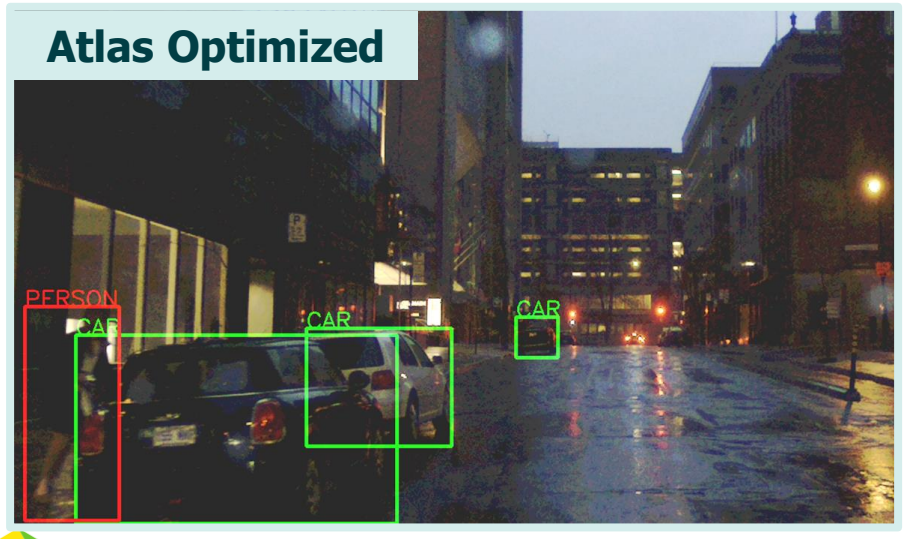
Visualization of TDA4 Atlas ISP Optimization

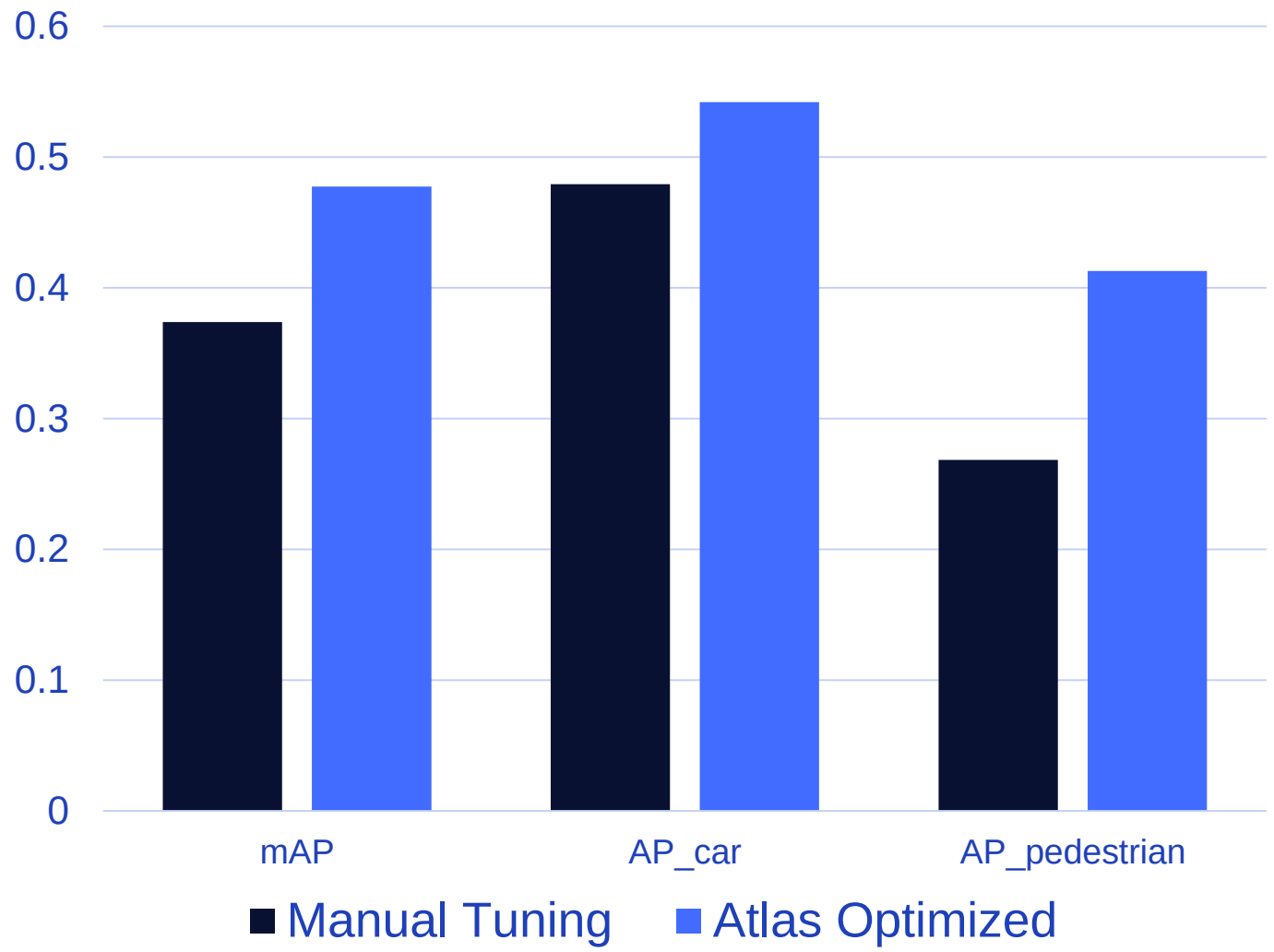


Case Study 2

Optimization Results: Improved Precision

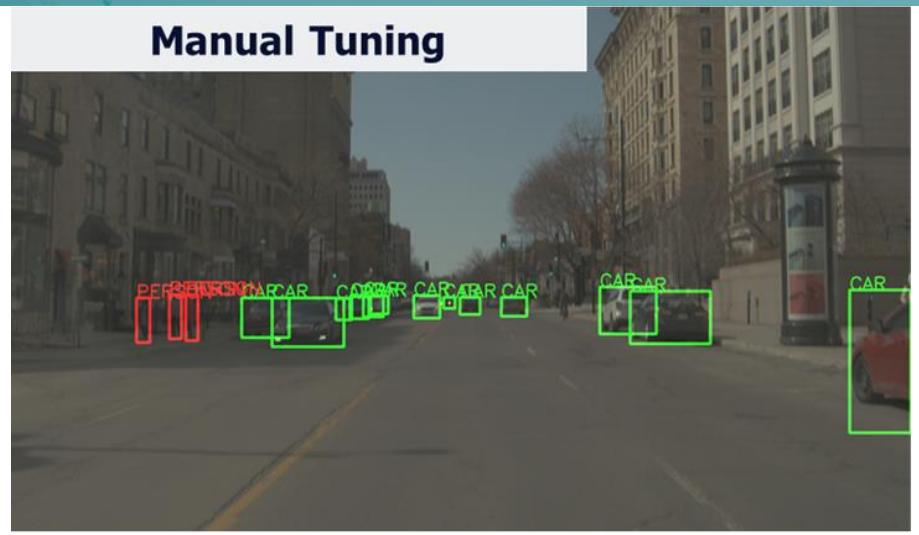


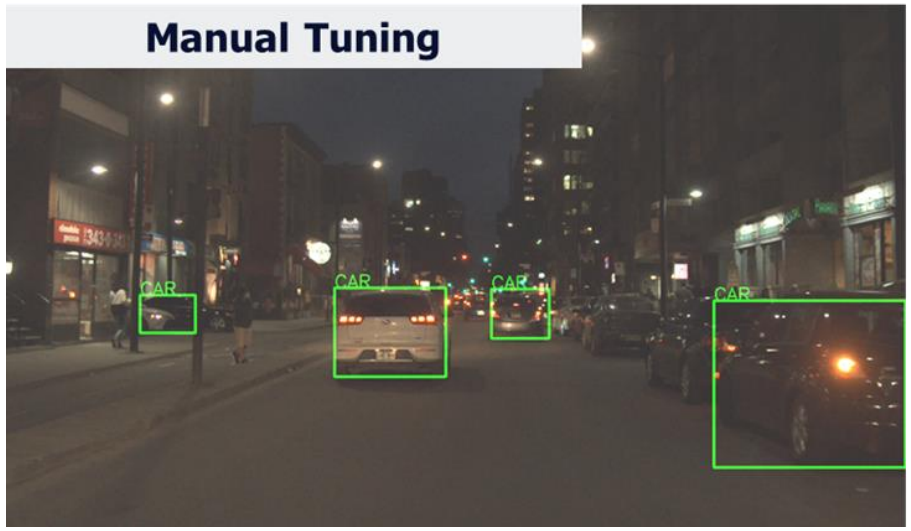


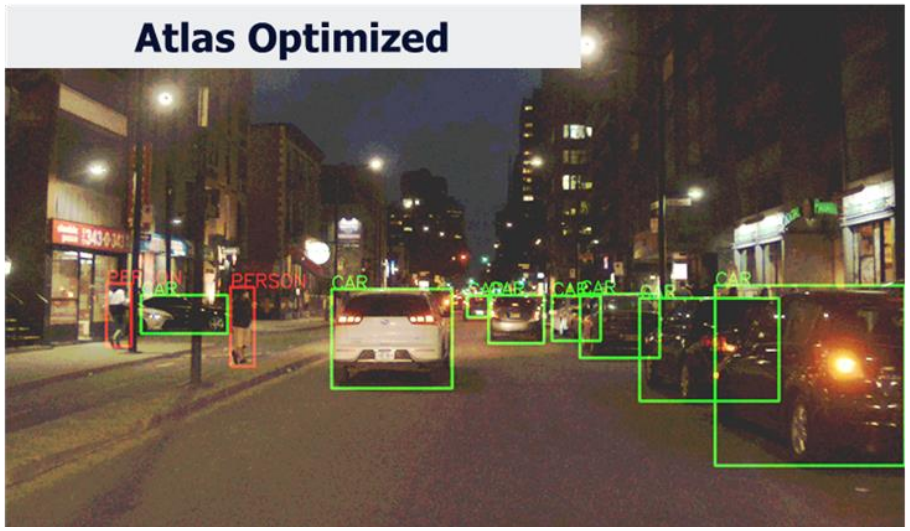


Case Study 2

Atlas Optimization: Improved Results in High & Low Lighting

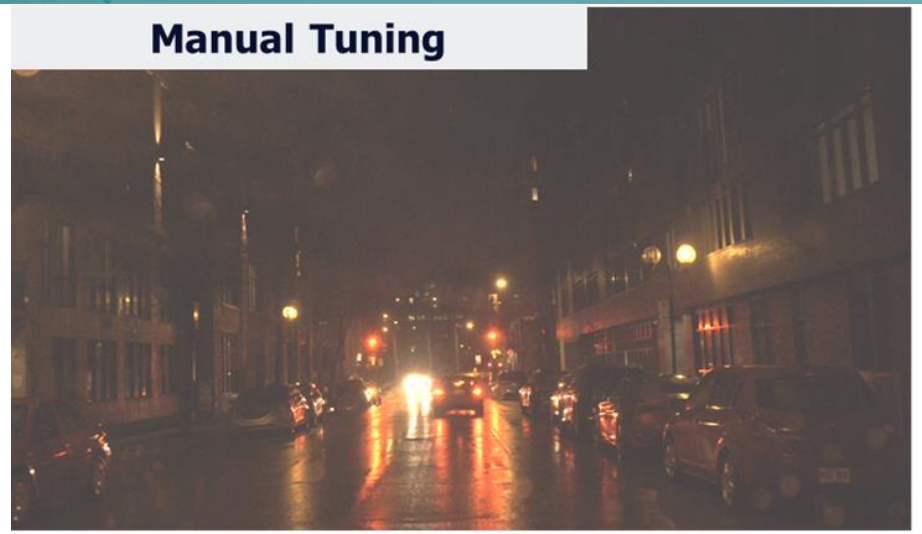


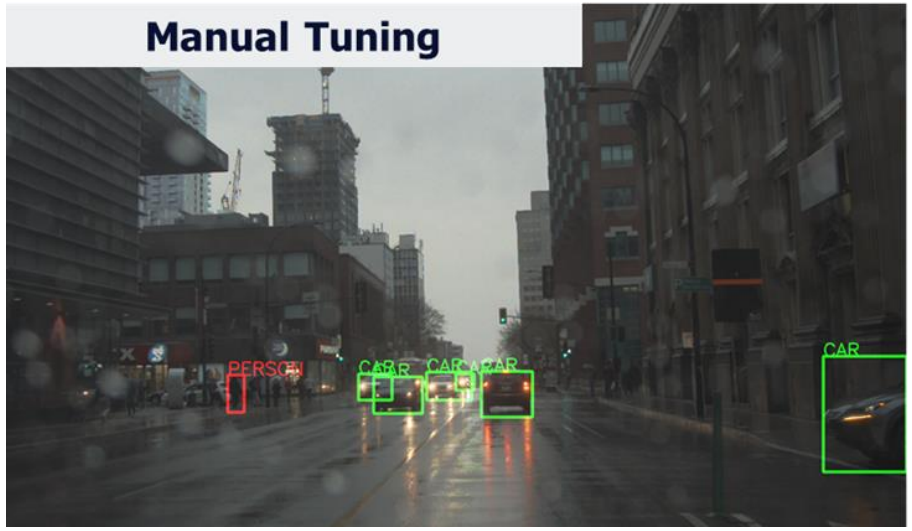




Case Study 2

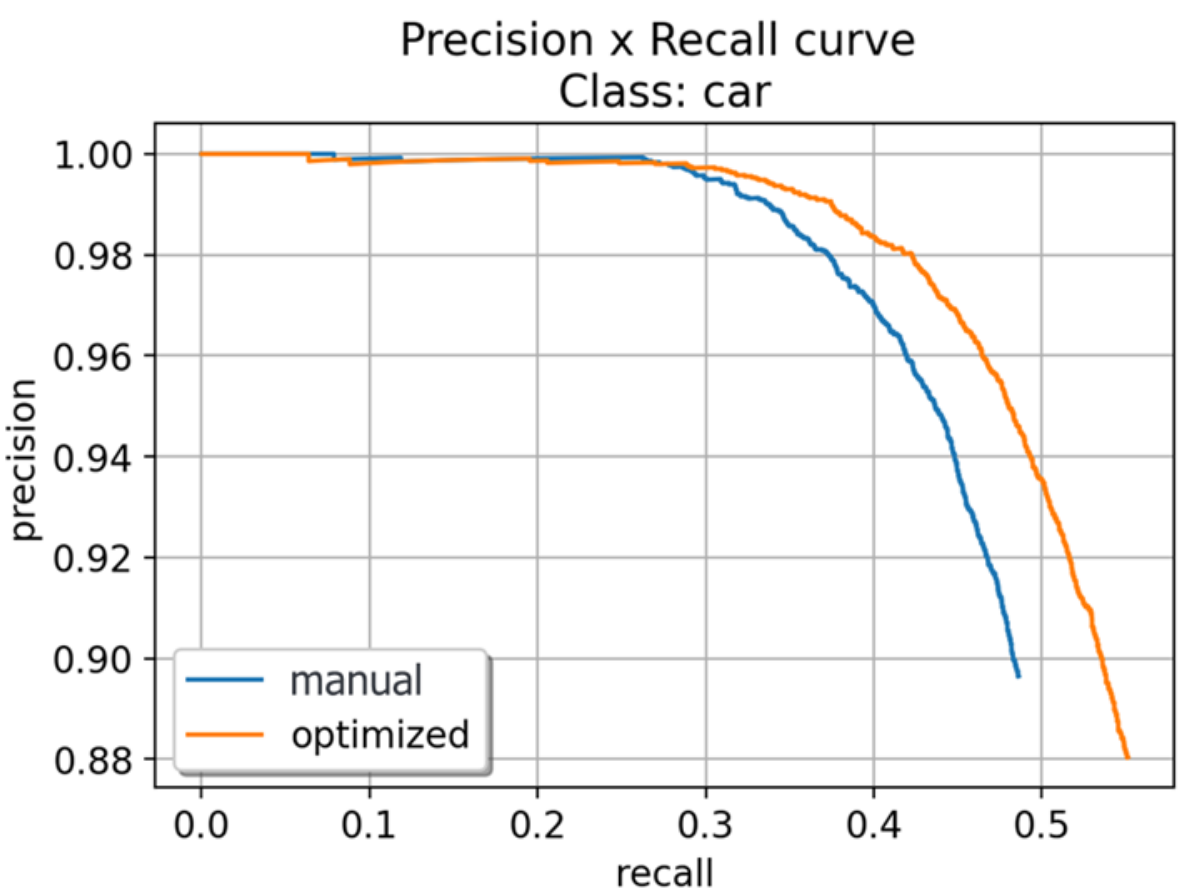
Atlas Optimization: Improved Results in Low Light and Poor Weather

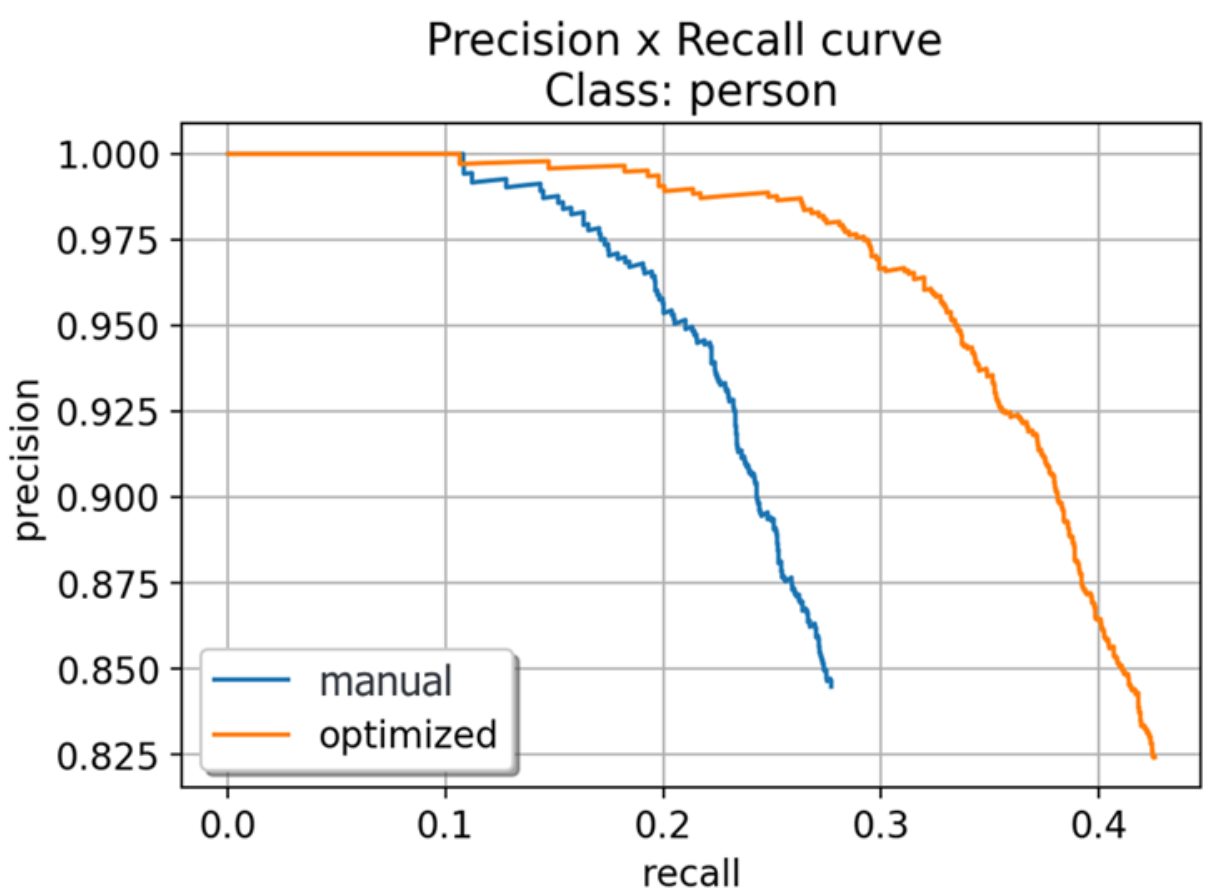




Case Study 2

Atlas Optimization Achieves Holistically Better Computer Vision Results





Atlas-optimized ISP results outperform default ISP tuning throughout the confidence threshold

Case Study 2

Case Study Summary

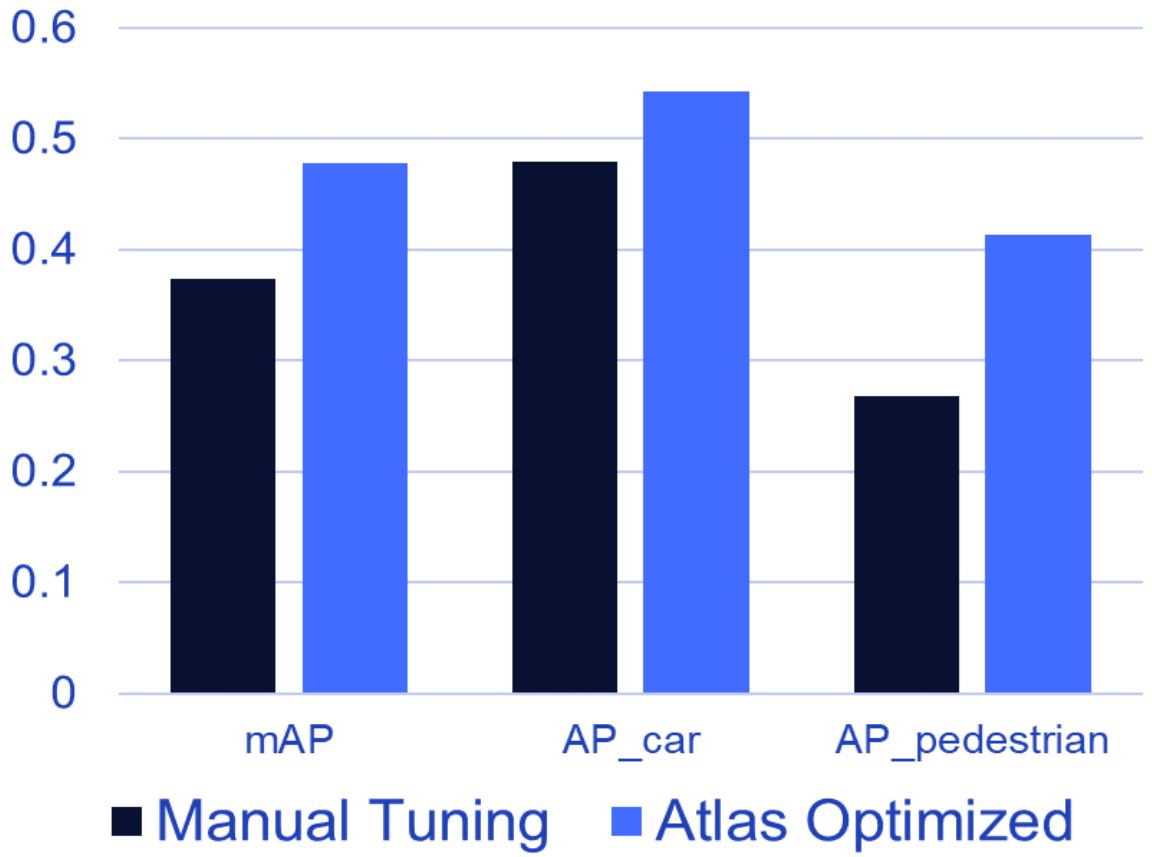
Objective: Maximize object detection results of a front facing ADAS camera by automatically optimizing TI TDA4 ISP camera parameters

Camera configuration

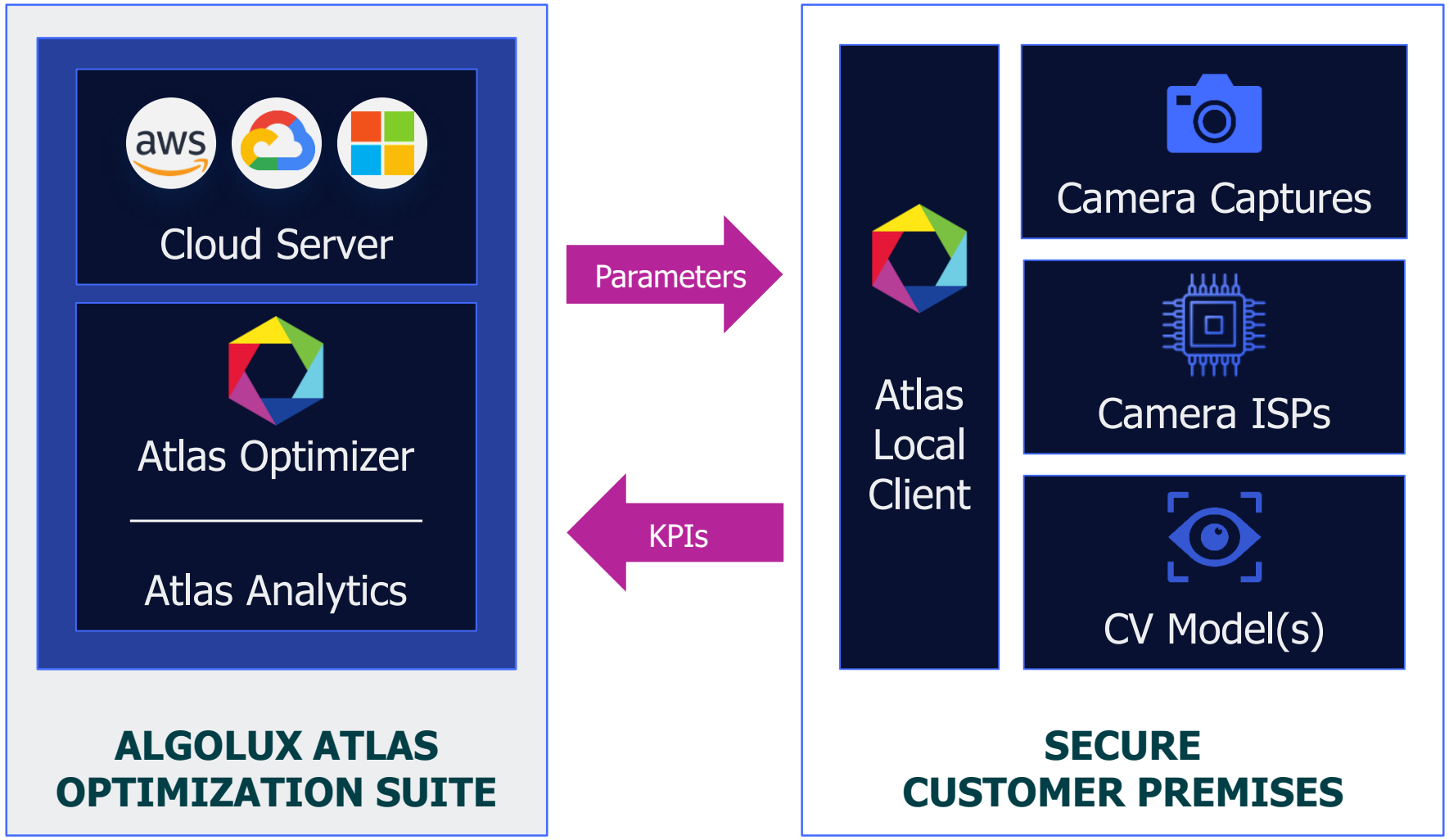
- TI TDA4VM SoC ISP
- Sony IMX490 5.44 MP HDR sensor
- YOLOv4 object detector

Atlas results for YOLOv4 detector

- 10.4% mAP improvement vs. manual tuning
- Large 30 parameter space optimized
- Fast time to results: 1000 trials in ~48 hrs



Conclusion: Algolux Delivers the Industry's First Automated ISP Optimization in the Cloud with Atlas



Efficient
Get results in just days

Scalable
Any CV task and camera

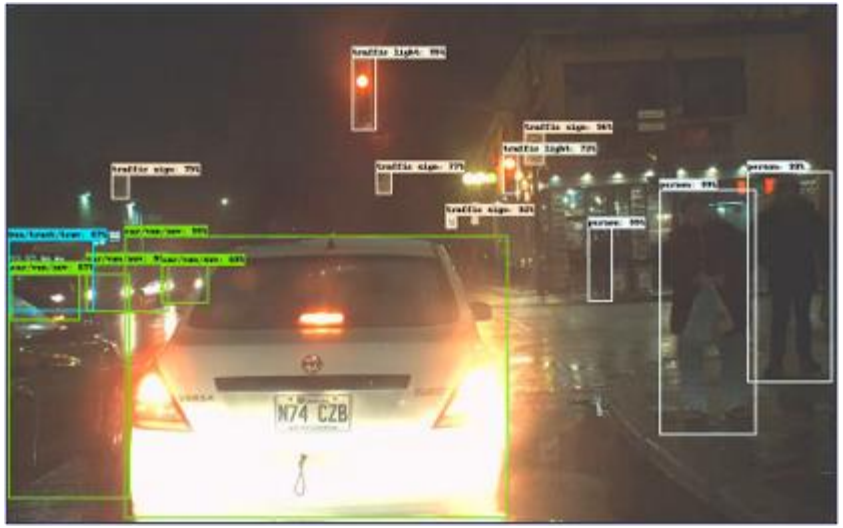
Optimal
Maximize CV results

Objective
Results driven by clear metrics

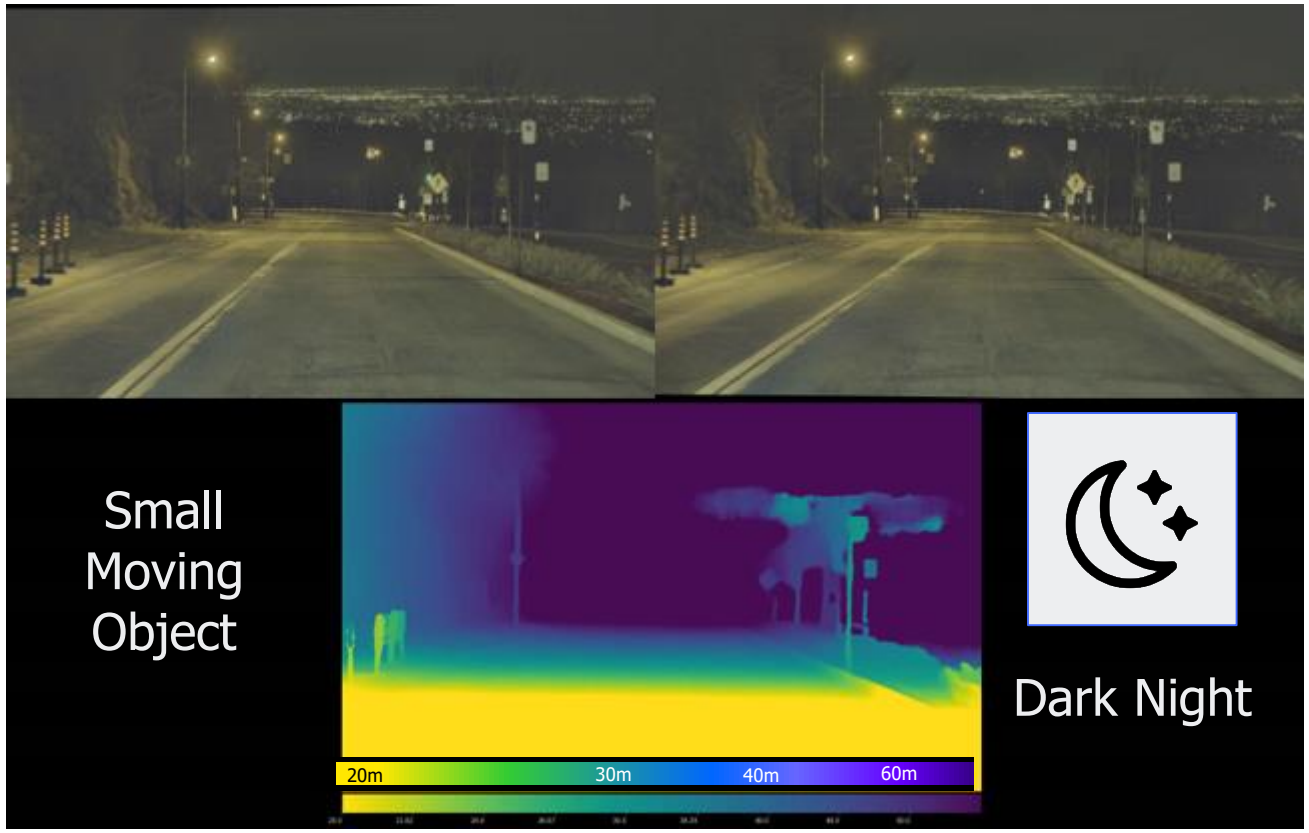
Teaser: Taking Vision Robustness to the Next Level

Eos Learned End-to-End Robust Detection and Multi-Camera Depth

Dark Night



Foggy Night



Algolux Resource Slide

Resource Links

Algolux Edge AI & Vision Alliance page

- https://www.edge-ai-vision.com/companies/algolux

Algolux homepage

- https://www.algolux.com

Atlas ISP optimization case study with a leading automotive Tier 1

- Atlas Case Study Link

2022 Embedded Vision Summit

Visit us at Booth 613 and see the following Algolux demos:

- Atlas ISP Optimization Suite Evaluation Platform
- Eos Robust Embedded Perception Software

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