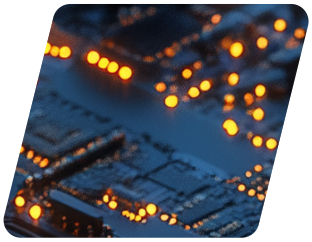
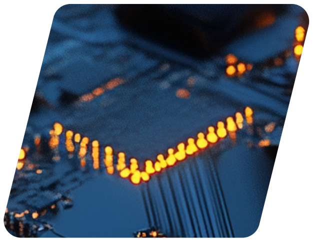
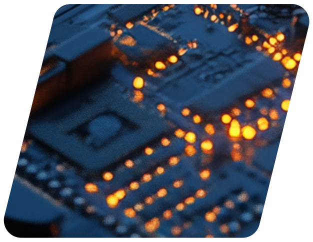
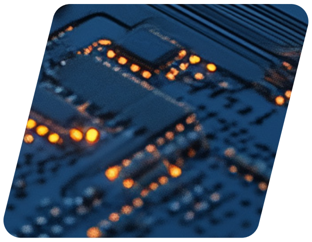
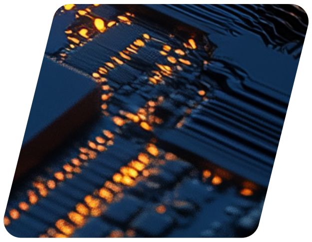




Multi-object Detection at the Far Edge with Lattice sensAI™ 8.0

White Paper

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ABSTRACT

Multi-object detection is a foundational capability for modern edge vision systems, enabling real-time identification and localization of multiple objects under strict power, latency, and system-cost constraints. As perception workloads move closer to the sensor, traditional CPU- and accelerator-based approaches often struggle to balance accuracy with deterministic performance and long product lifecycles. This white paper examines how Lattice sensAI 8.0 enables efficient multi-object detection at the far edge using low power FPGA platforms. It introduces two production-oriented models available in the sensAI 8.0 Model Zoo: a Generic Multi-object Detection model designed for broad adaptability across domains, and an Automotive-focused Multi-object Detection model optimized for scope-controlled, automotive-adjacent perception scenarios. The paper compares their architectural commonalities and practical differences, discusses performance metrics in the context of fixed-point, deterministic edge deployment, and provides guidance on selecting the appropriate model based on application requirements to support scalable, efficient, and adaptable edge vision systems.

GLOSSARY

- **MOD** – Multi-object Detection
- **FPGA** – Field Programmable Gate Array
- **mAP** – Mean Average Precision
- **COCO** – Common Objects in Context
- **Anchor-free Detectio**n – Detection approach without predefined anchor boxes

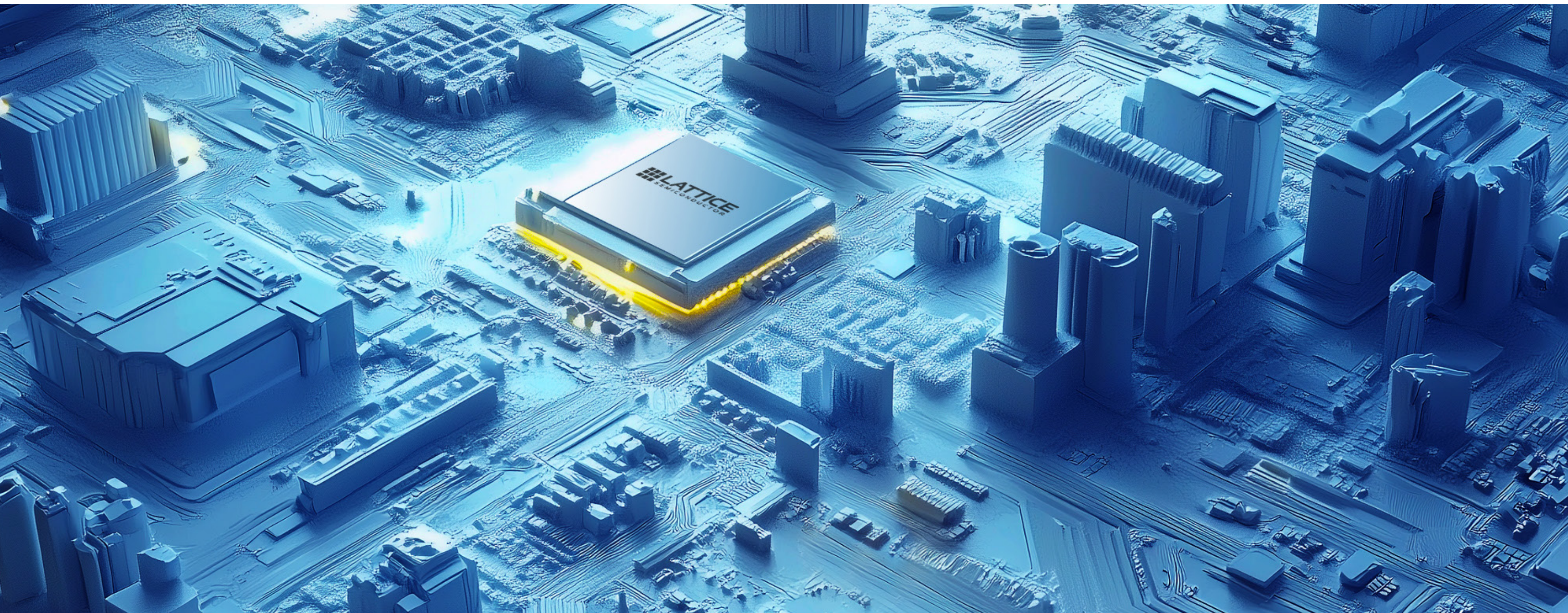

TABLE OF CONTENTS

Introduction

Multi-object detection (MOD) has become a foundational capability for edge vision systems, enabling machines to identify and localize multiple objects simultaneously under real-time constraints. As these systems move closer to the sensor, designers must balance accuracy with strict limits on power, latency, and system cost. The Lattice sensAI™ version 8.0 solution stack addresses this challenge by enabling modern, multi-scale object detection pipelines on low power FPGA platforms. Within the sensAI 8.0 Model Zoo, Lattice provides both a generic multi-object detection model, designed for broad applicability and adaptability, and an automotive-focused multi-object detection model, tailored for automotive-oriented perception scenarios. Together, these models illustrate how a common architectural foundation can be adapted to meet diverse deployment needs while maintaining deterministic performance and efficiency at the far edge.

The Challenge of Multi-object Detection at the Far Edge

Multi-object detection is computationally demanding by nature. Unlike single-object or classification workloads, MOD systems must simultaneously perform feature extraction, multi-scale inference, object localization, and classification, often across dynamic scenes with varying object sizes and densities. When deployed at the far edge, these requirements collide with a distinct set of constraints:

- **Power and thermal limits:** Many edge systems operate continuously within sub-watt power envelopes
- **Latency and determinism:** Vision pipelines must deliver consistent real-time behavior
- **Memory and bandwidth constraints:** Near-sensor devices often lack the external memory capacity assumed by cloud-era models
- **Long product lifecycles:** Edge systems must evolve over many years without hardware replacement

Conventional AI acceleration approaches struggle under these conditions. CPU-based inference often fails to meet real-time requirements, while fixed-function accelerators limit adaptability as detection architectures evolve. Deploying modern multi-object detection at the far edge therefore remains a non-trivial engineering challenge.

Market and Technology Drivers Shaping Adoption

The demand for edge-based perception continues to accelerate as intelligence shifts from centralized cloud infrastructure toward distributed, near-sensor processing[1]. Key drivers include latency sensitivity, data locality, privacy, and the need for scalable deployments.

Market research projects strong growth in embedded and edge AI hardware through the second half of the decade, driven by vision-centric applications across automotive-adjacent sensing, smart infrastructure, robotics, and security.[2] At the same time, modern object-detection architectures increasingly rely on anchor-free, multi-scale designs that improve accuracy but increase architectural complexity.[3,4,5]

These trends converge on a central challenge: deploying sophisticated perception models under strict power, cost, and determinism constraints. This is the context in which Lattice sensAI 8.0 is positioned.

Enabling Multi-object Detection with Lattice sensAI 8.0

The Lattice sensAI 8.0 solution stack provides an integrated platform for deploying multi-object detection at the far edge, combining production-oriented models, deployment-accurate tooling, and resource-efficient FPGA acceleration.

Key features:

- A unified Model Zoo with structured model cards
- Quantization and simulation tools that reflect fixed-point, on-device behavior
- A neural network compiler and ML accelerator IP optimized for low-power FPGAs
- Validated reference platforms to accelerate prototyping and integration

This co-designed approach allows developers to evaluate accuracy, performance, and resource trade-offs early in the design cycle.

Generic and Automotive-focused Multi-object Detection Models

Positioning Generic and Automotive-focused MOD Models

Within sensAI 8.0, the Generic MOD and Automotive MOD models share a common architectural foundation but differ in scope and deployment intent. The Generic MOD model emphasizes breadth and adaptability, while the Automotive MOD model focuses on a constrained set of automotive-oriented object classes and evaluation contexts.

Generic Multi-object Detection Model

The Generic MOD model is designed as a broad, adaptable baseline. It is trained on the full Common Objects in Context (COCO) dataset and supports diverse application domains such as smart infrastructure, robotics, and security. The Generic MOD model prioritizes flexibility and adaptability within the constraints of low power FPGA deployment.

Key characteristics:

- Broad class coverage (COCO 80 classes)
- Suitable for fine-tuning and domain adaptation
- YOLO-like anchor-free architecture with three detection scales
- Separate outputs for classes and bounding boxes
- Offline evaluation using COCO validation datasets

Automotive-focused Multi-object Detection Model

The Automotive MOD model is tailored for automotive-oriented perception scenarios with a deliberately constrained scope. It is trained to detect exactly eight object categories. The Automotive MOD model is positioned as a scope-controlled specialization suitable for automotive-adjacent use cases, without implying safety certification.

Object categories:

- Person
- Bicycle
- Car
- Motorcycle
- Bus
- Truck
- Traffic light
- Stop sign

Key characteristics:

- Explicitly defined automotive-focused class set
- Same YOLO-like anchor-free architecture as Generic MOD
- Three detection scales with separated outputs
- Evaluation aligned with automotive-oriented imagery and object-size considerations
- Production-oriented configuration for edge FPGA deployment

Architectural Commonalities and Practical Differences

Both models share a set of core architectural principles that enable performance, efficiency, and toolchain compatibility.

Shared set of core architectural principles:

- YOLO-like anchor-free architecture with three detection scales
- Separated classification and localization outputs
- Fixed input resolution (384 × 288 RGB), optimized for fixed-point FPGA execution
- Embedded-optimized parameterization
- Compatibility with the sensAI 8.0 toolchain

Table 1 shows the key practical differences between both models.

Table 1: Key Practical Differences

DIMENSION	GENERIC MOD	AUTOMOTIVE MOD
Training scope	Broad, multi-domain	Narrow, automotive-focused
Object classes	COCO (80 classes)	8 defined classes
Evaluation	Offline, general-purpose	Automotive-oriented
Primary goal	Flexibility	Predictability

Interpreting Performance Metrics for Edge MOD

Performance metrics must be interpreted in context. Edge deployments differ from cloud benchmarks due to fixed-point inference, deterministic execution, and constrained memory.[6,7]

Key considerations:

- mAP values are relative indicators, not guarantees
- Dataset scope and filtering significantly affect results
- Object-size filtering improves deployment realism
- Quantization effects are included in reported metrics

Metrics support informed design decisions but should not be over-interpreted as system-level guarantees.

Conclusion

Multi-object detection at the far edge requires architecture and tools designed for power efficiency, determinism, and long lifecycle support. The Lattice sensAI 8.0 solution stack enables modern object detection on low power FPGAs through a unified platform and production-oriented models. By offering both Generic and Automotive-focused MOD models, Lattice delivers a clear framework for aligning detection pipelines with application needs while maintaining efficiency at the far edge.

Appendix

Table 2: Performance Metrics Summary (Selective)

Generic MOD (Offline Evaluation)	Automotive MOD
COCO 80-class validation: mAP@0.5 ≈ 0.39	COCO 8px-filtered: mAP@0.5 ≈ 0.61
COCO automotive-class subset: mAP@0.5 ≈ 0.44	COCO 20px-filtered: mAP@0.5 ≈ 0.71

All metrics sourced directly from model cards.

References

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[5] Ultralytics — Anchor-Free Detection Overview

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[7] IEEE — Deterministic Computing for Edge Systems

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