



Designing **Smarter and Safer Cars** with Essential AI

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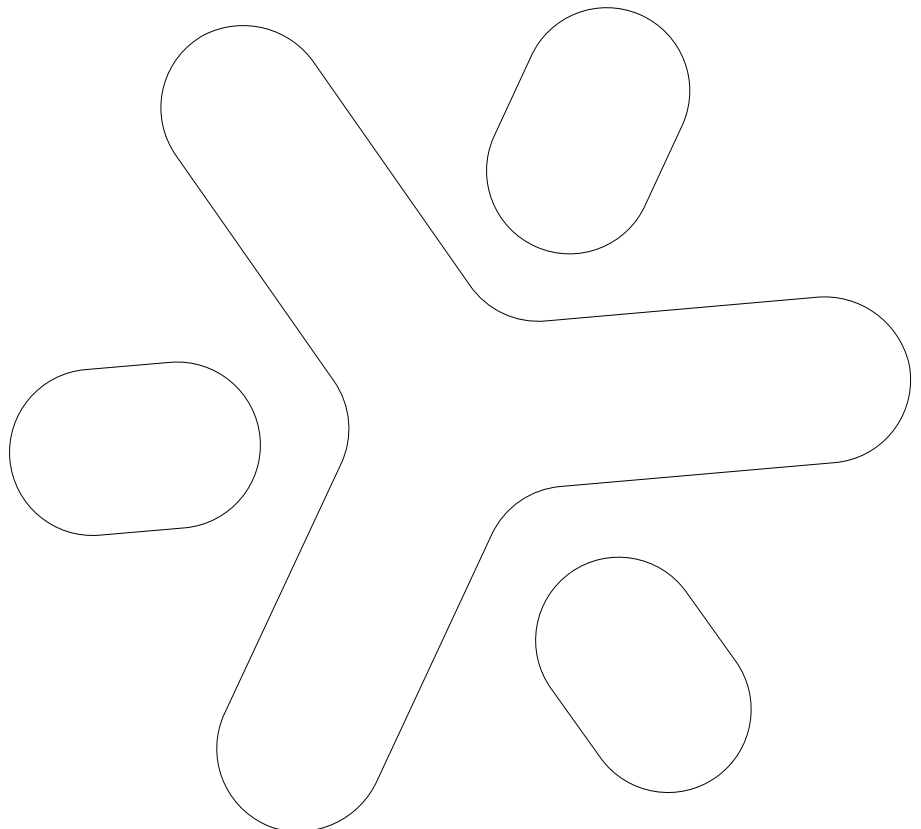
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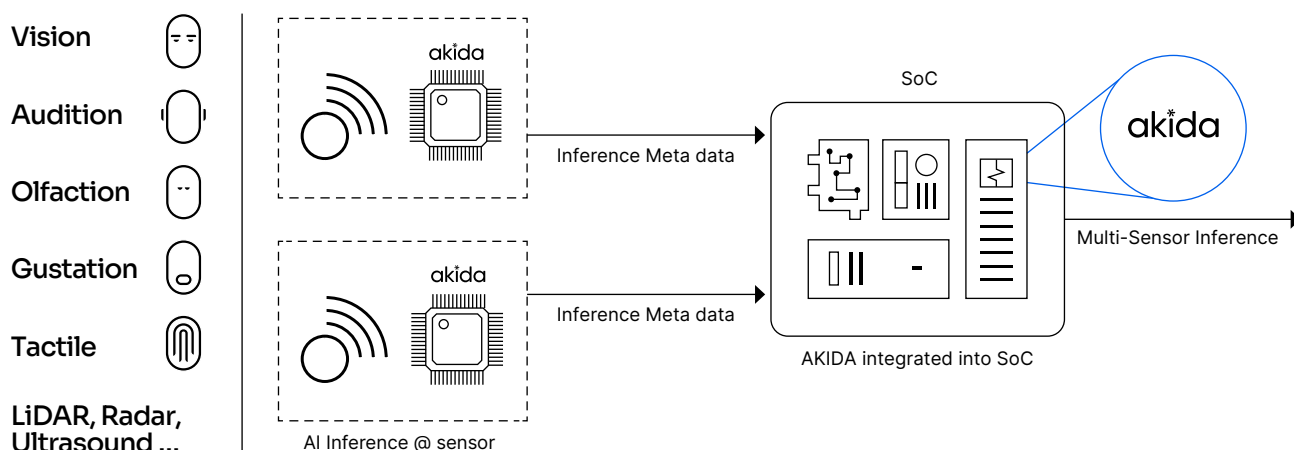
Introduction

Conventional AI silicon and cloud-centric inference models do not perform efficiently at the automotive edge. As many semiconductor companies have already realized, latency and power are two primary issues that must be effectively addressed before the automotive industry can manufacture a new generation of smarter and safer cars. To meet consumer expectations, these vehicles need to feature highly personalized and responsive in-cabin systems while supporting advanced assisted driving capabilities.

In this paper, we discuss how automotive companies are redefining the in-cabin experience and accelerating assisted driving capabilities by untethering edge AI functions from the cloud - and performing distributed inference computation on local neuromorphic silicon using BrainChip's AKIDA. We call this Essential AI.

This model sequentially leverages multiple AKIDA-powered smart sensors and AKIDA AI SoC accelerators to efficiently capture and analyze inference data within designated regions of interest or ROI (samples within a data set that provide value for inference). AI inference at the automotive edge starts with versatile AKIDA-powered smart sensors capturing entire input images and complete audio streams in real-time.

The raw data passes to AKIDA AI accelerators embedded on smart sensors - which analyze and infer meaningful information from specific regions of interest.



AI inference at the sensor and beyond

Refined data packets (inference metadata) are sent to additional AKIDA AI accelerators embedded in automotive head units and electronic control units (ECUs) for further analysis. By limiting inference to sensor-specific regions of interest, AKIDA significantly accelerates computation, decreases latency, and reduces energy consumption.

With AKIDA, automotive companies are designing lighter, faster, and more energy efficient in-cabin systems that can act independent of the cloud. These include advanced facial detection and customization systems that automatically adjust seats, mirrors, infotainment settings, and interior temperatures to match driver preferences. AKIDA also enables sophisticated voice control technology that instantly responds to commands - as well as gaze estimation and emotion classification systems that proactively prompt drivers to focus on the road.

In addition to redefining the in-cabin experience, AKIDA allows advanced driver assistance systems (ADAS) such as computer vision and LiDAR to detect vehicles, pedestrians, bicyclists, signs, and objects with incredibly high levels of precision. Moreover, AKIDA optimizes power, performance, and area (PPA) to significantly reduce the size of ADAS components - and eliminates the need for general-purpose, compute-heavy CPUs and GPUs that demand large carbon footprints.

Scalable AKIDA-powered smart sensors bring common sense to the processing of automotive data - freeing ADAS and in-cabin systems to do more with less by allowing them to infer the big picture from the basics. With AKIDA, automotive manufacturers are designing sophisticated edge AI systems that deliver immersive end-user experiences, support the ever-increasing data and compute requirements of assisted driving capabilities, and enable the self-driving cars and trucks of the future.

Chapter 1

In-Cabin Experience

According to [McKinsey analysts](#), the in-cabin experience is poised to become one of the most important differentiators for new car buyers. In recent months, major automotive manufacturers such as Mercedes-Benz have debuted concept cars equipped with smart sensors and advanced AI capabilities that highlight a more personalized, responsive, and immersive in-cabin experience.

Five driving forces can be expected to shape cabin experience through 2030.				
New Vehicle Types	Connectivity and HMI ¹	Comfort	Sustainability	Cost Efficiency
A shift to electric, shared and autonomous vehicles will have a massive impact on interior layout.	Trend toward huge displays could be reversed (eg, through holographic systems); voice may become the predominant input; rise of post-purchase features	Increasingly "homelike" trim and customizable cabin experience	Green interior will contribute to ambitious decarbonization targets; increasingly asked for even by high-end customers	Amplitude of interior trends will increase cost pressure for nonvisible/non-value-adding components

The evolution of the in-cabin experience (McKinsey & Company, The future of interior in automotive, November 12, 2021)

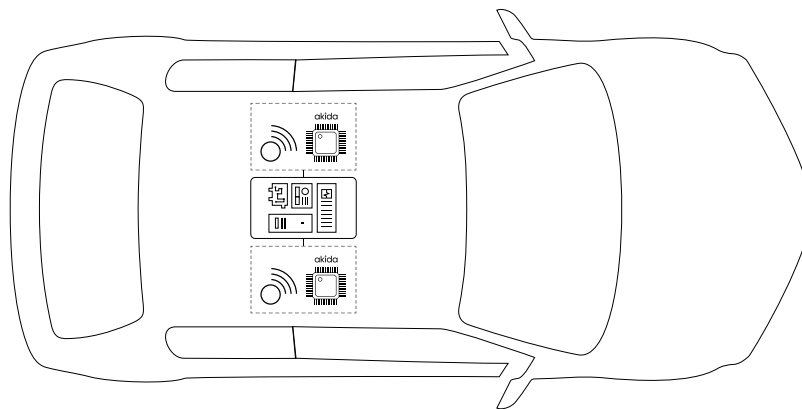
For example, the Vision EQXX features an expansive 8K LCD touchscreen display that spans the entire width of the dashboard. The touchscreen display provides [real-time data visualization](#) of the VISION EQXX's energy usage, aerodynamics performance, range prediction, solar generation, and wind conditions. While most dashboard screens are continuously backlit, the EQXX display includes 3,000 micro-LEDs which can be [individually dimmed](#). The futuristic electric car also embeds speakers and subwoofers in headrests and seat-back cushions, allowing passengers to listen to their own music and podcasts without disturbing others.

In addition, the EQXX features [AKIDA-powered neuromorphic AI voice control technology](#) which is five to ten times more efficient than conventional systems. With AKIDA, [in-cabin systems detect actionable information](#) within specific ROIs to instantly respond to voice commands and hand gestures, reliably identify and authenticate drivers, as well as accurately monitor steering wheel movements and driver alertness.



The Mercedes-Benz VISION EQXX interior

By limiting inference to a ROI, AKIDA minimizes the size and complexity of data packets sent to AI accelerators embedded in automotive head units. This significantly decreases latency, accelerates computation, and minimizes energy requirements for in-cabin systems.



Transforming the in-cabin experience with AKIDA

Neuromorphic silicon - which processes data with efficiency, precision, and economy of energy - is playing a major role in transforming vehicles into transportation capsules with personalized features and applications to accommodate both work and entertainment. This evolution is driven by smart sensors capturing yottabytes of data from the automotive edge to create holistic and immersive in-cabin experiences.

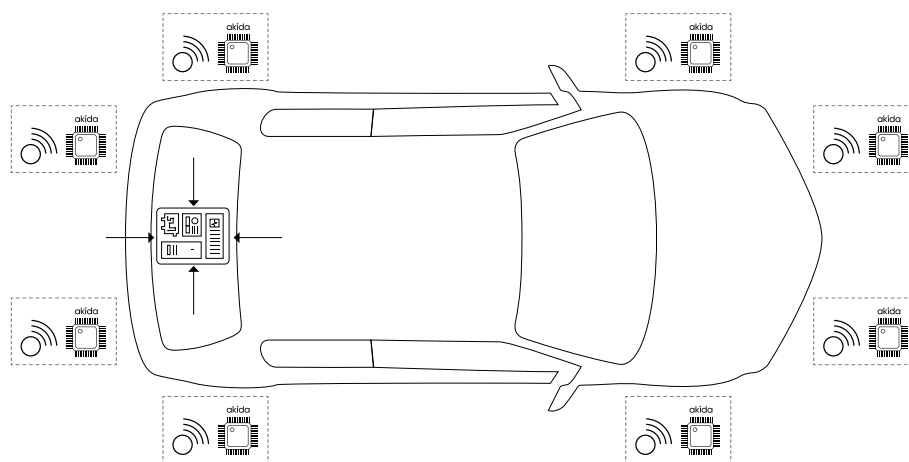
[As inventor Carver Mead notes](#), neuromorphic compute architectures learn to understand their environment and are often “many orders of magnitude more effective” than conventional systems. With AKIDA silicon, automotive manufacturers are leveraging the principles of neuromorphic computing to design more intelligent and personalized vehicle interiors that efficiently adapt to drivers and passengers.

Chapter 2

Assisted Driving – Computer Vision

Several automotive manufacturers have successfully developed Level 1 and Level 2 assisted driving systems using computer vision and single-shot object detection algorithms such as YOLO. Although single-shot object detection algorithms are known for their computational efficiency, this approach to real-time inferencing is closely tied to a cloud-based computing paradigm that is inefficient at the automotive edge.

To accelerate the development of Level 3 assisted driving systems, we propose pairing two-stage object detection inference algorithms with a local sequential neuromorphic processing model. Leveraging AKIDA-powered smart sensors and AI accelerators, this edge-based computer vision paradigm efficiently performs processing in two primary stages - at the sensor (inference) and AI accelerator (classification).



Transforming the in-cabin experience with AKIDA

As the diagram above page illustrates, this multi-tiered processing model comprises:

- ⌘ **AKIDA-Powered Smart Sensors:** Embedded in ADAS computer vision systems, these smart sensors generate full and detailed input images of their surroundings.
- ⌘ **AKIDA AI Accelerators:** AKIDA AI accelerators on smart sensors intelligently process these complete and data-heavy images. Only image regions that likely contain important classes - such as pedestrians, cars, trucks, bicycles, and pets - are sent to the next stage for processing. The pared down inference data includes the x,y location of the images to be classified, along with the selected image region.

- ⊛ **ADAS ECUs:** Refining inference data eliminates the need for compute-heavy hardware such as general-purpose CPUs and GPUs that draw considerable amounts of power and increase the size and weight of computer vision systems. With AKIDA accelerators, ADAS electronic control units efficiently classify selected image regions (region proposals) without leveraging additional systems or hardware.

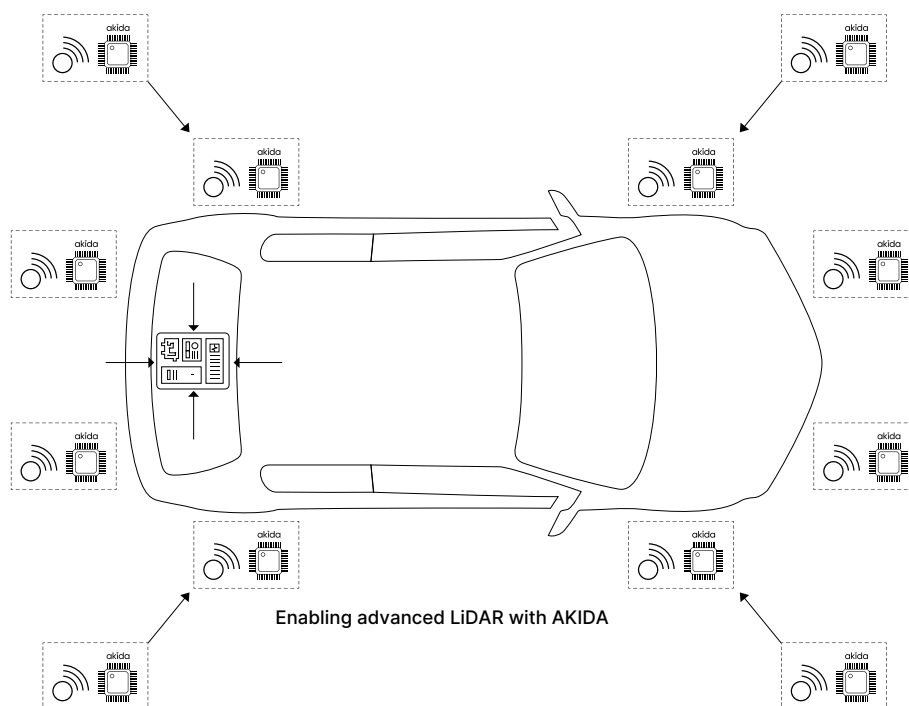
With a multi-tiered implementation of smart sensors and AI accelerators, automotive computer vision systems rapidly and efficiently analyze vast amounts of inference data within specific ROIs. ADAS leverages the refined data to generate detailed 3D maps that help drivers safely navigate and avoid accidents by accurately identifying and displaying the location of lanes, road curves, people, vehicles, and obstacles.

Chapter 3

Assisted Driving – LiDAR

Many vehicles with advanced Level 2 driver assistance systems, including those manufactured by Waymo and Toyota, use LiDAR to navigate streets and highways. Although these systems accurately detect stationary objects, conventional LiDAR cannot track or identify moving objects with the same level of precision. In addition, most LiDAR systems leverage general-purpose GPUs and run cloud-centric, compute-heavy inference models that demand a large carbon footprint to process enormous amounts of data. Indeed, LiDAR sensors typically fire 8 to 108 laser beams in a series of cyclical pulses - each emitting billions of photons per second. These beams bounce off objects and are analyzed to identify and classify vehicles, pedestrians, animals, and street signs.

To efficiently process millions of data points simultaneously, we propose designing new LiDAR systems that leverage the principles of sequential computation with AKIDA-powered smart sensors and AI accelerators. This approach enables automotive manufacturers to significantly improve the inferential capabilities, scalability, and energy efficiency of LiDAR.



As the diagram on the previous page illustrates, this sequential computational model comprises:

- ⊛ **AKIDA-Powered Smart Sensors:** Smart sensors with ranges of 250 to 400 meters are placed on the vehicle roof, behind the grille, within the rearview mirror, and embedded in the rear window or tailgate. These smart sensors analyze entire data-heavy input images in real-time - and intelligently extract meaningful information from within specific regions of interest with embedded AI accelerators.
- ⊛ **AKIDA AI Accelerators:** By limiting inference to a ROI, AKIDA AI accelerators help LiDAR systems more efficiently detect moving vehicles, pedestrians, animals, and objects. In addition, AKIDA AI accelerators on smart sensors reduce latency by minimizing the size and complexity of inference data packets sent to AI accelerators embedded in ADAS ECUs.
- ⊛ **ADAS ECUs:** AKIDA AI accelerators embedded in ADAS ECUs further analyze actionable LiDAR inference data to precisely classify and identify vehicles, pedestrians, animals, street signs, and objects. By refining inference data, AKIDA eliminates the need for compute and energy heavy hardware such as general-purpose CPUs and GPUs that increase the size and weight of LiDAR systems.

With AKIDA, LiDAR uses minimal amounts of compute power to accurately detect - and classify - moving and stationary objects with equal levels of precision. This data is leveraged by ADAS systems to generate real-time 3D maps that help drivers safely navigate even the busiest streets and highways.

Conclusion

Conventional AI silicon and cloud-centric inference models do not perform efficiently at the automotive edge. This makes it challenging to manufacture vehicles with highly personalized in-cabin systems and advanced assisted driving capabilities. To speed up the development of smarter and safer vehicles, innovative automotive companies are untethering edge AI functions from the cloud - and performing distributed inference computation on local neuromorphic AKIDA silicon.

With AKIDA-powered smart sensors and AI accelerators, automotive companies are designing lighter, faster, and more energy efficient in-cabin systems that enable advanced driver verification and customization, sophisticated voice control technology, and next-level gaze estimation and emotion classification capabilities.

In addition to redefining the in-cabin experience, AKIDA supports new computer vision and LiDAR systems that detect vehicles, pedestrians, bicyclists, street signs, and objects with incredibly high levels of precision. These fast and energy efficient ADAS systems are already helping automotive companies accelerate the rollout of increasingly advanced assisted driving capabilities.

To learn more about designing **smarter and safer cars** with Essential AI, visit brainchip.com.



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