



Entering the Era of Multimodal Perception

Simon C. Morris

Serial Tech Entrepreneur and Start-Up Advisor
Connected Vision Advisors

Generative AI – All the Buzz

Generate content, like:

1. Writing articles
2. Composing music
3. Designing graphics
4. Generating code
5. Etc...

[Forbes 20Oct 2023: The 10 Biggest Generative AI Trends For 2024](#)

There's Another Opportunity



Reasoning is perhaps the ultimate goal of AI, but with human evolution it was both **multisensory integration** and reasoning that lead to life saving decisions.

Obvious examples:

- Sight + sound
- Smell + taste

Multisensory – Better Decisions – Safer



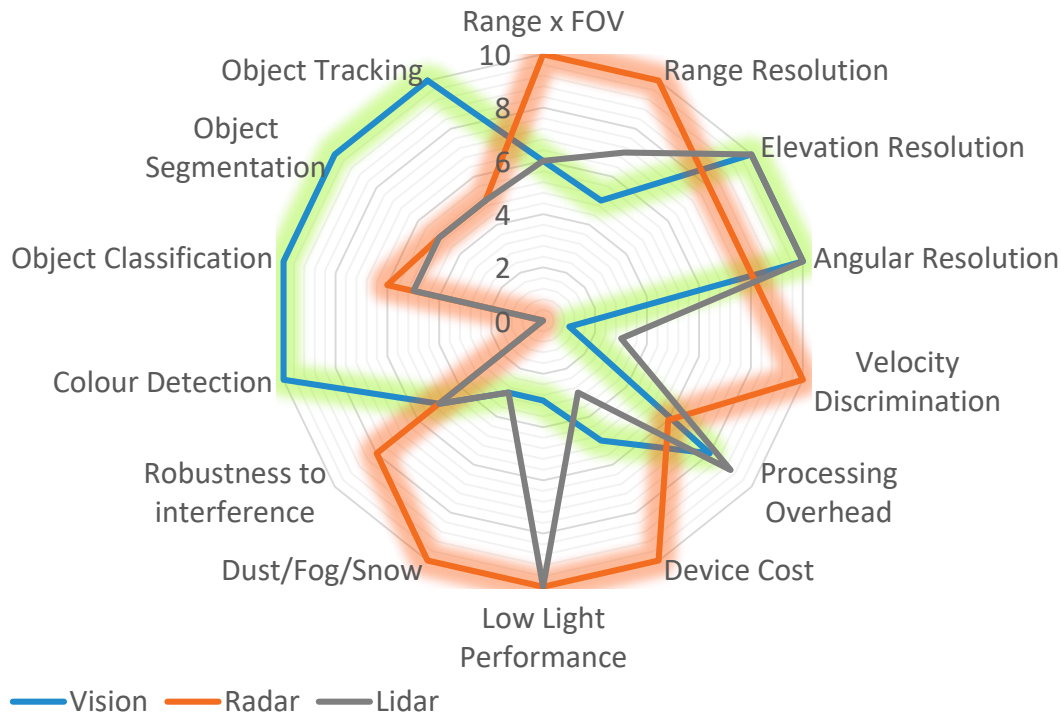
[This Photo](#) by Unknown Author is licensed under [CC BY-SA](#)

Multisensory Integration – Fusion on the Edge

- Sensor fusion - the process of combining sensor data or data derived from disparate sources
- The result - less uncertainty or a better decision compared to when the sensor sources were used individually.
- Edge perception today - combination of camera, lidar, time of flight (ToF), radar, ultrasonic, GPS sensor data

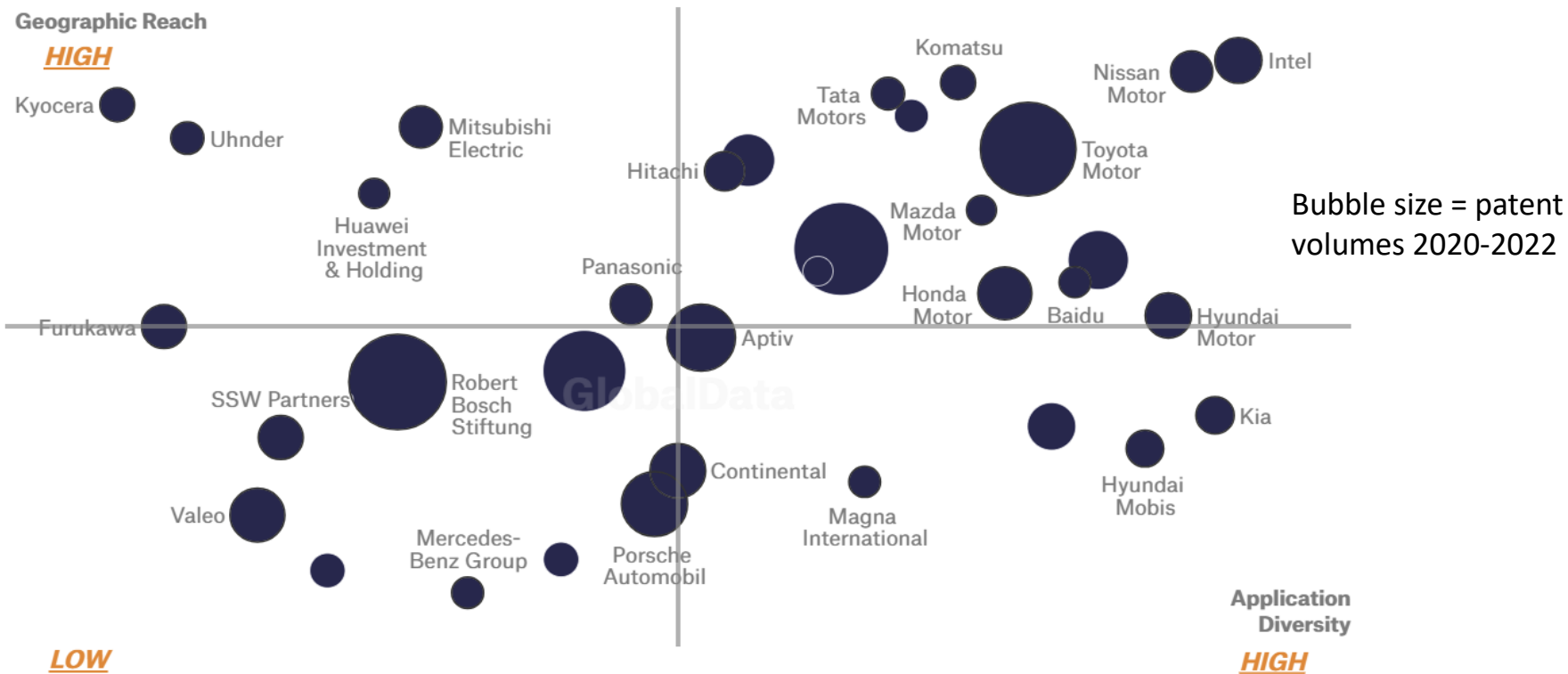
Proof of the Importance of Fusion Opportunity

In the last three years alone, there have been **over 1.7 million patents** filed and granted in radar-camera fusion



Source: GlobalData's report on Artificial Intelligence in Automotive: Radar Camera Fusion

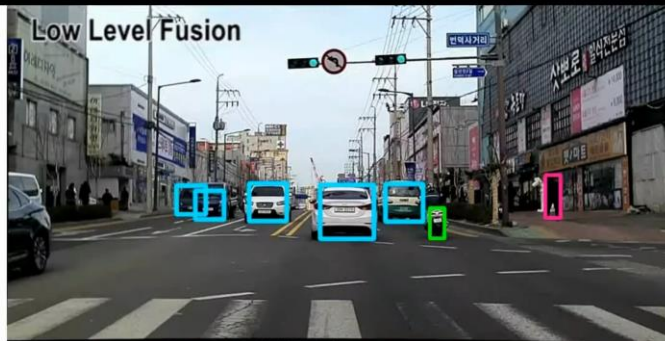
Fusion Patent Volume 2020-2022 – Automotive



Source: GlobalData Patent Analytics

Fusion for Edge Perception

Camera Ready Fusion



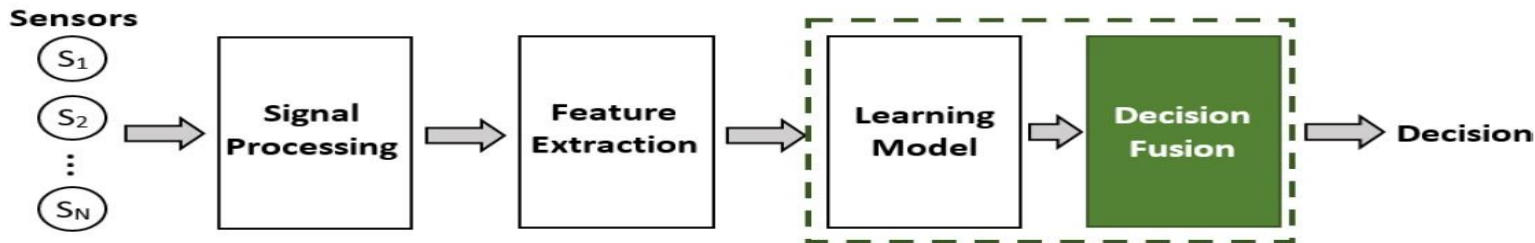
Ref: Junhyuk Hyun, Yonsei University
Korea, Computational Intelligence Lab



[Camera Radar Fusion - YouTube](#)

High-level fusion (decision fusion) - *incumbent*

- GPS + inertial navigation systems, or
- Fusing objects and trajectories of objects

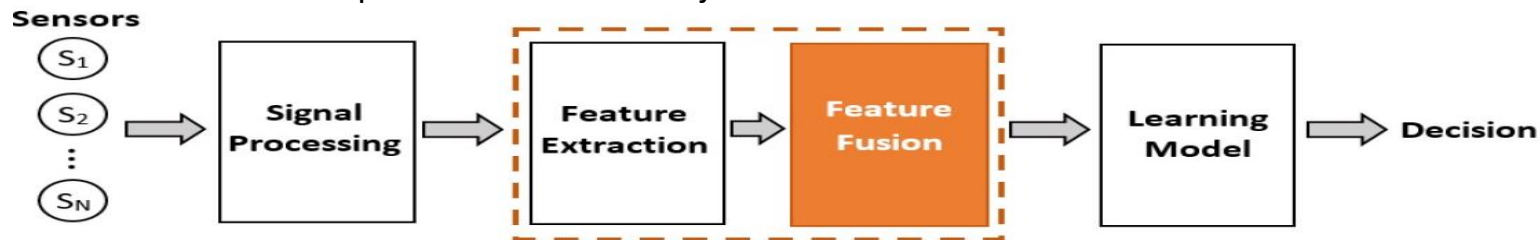


Fusion for Edge Perception – Where's It Going?

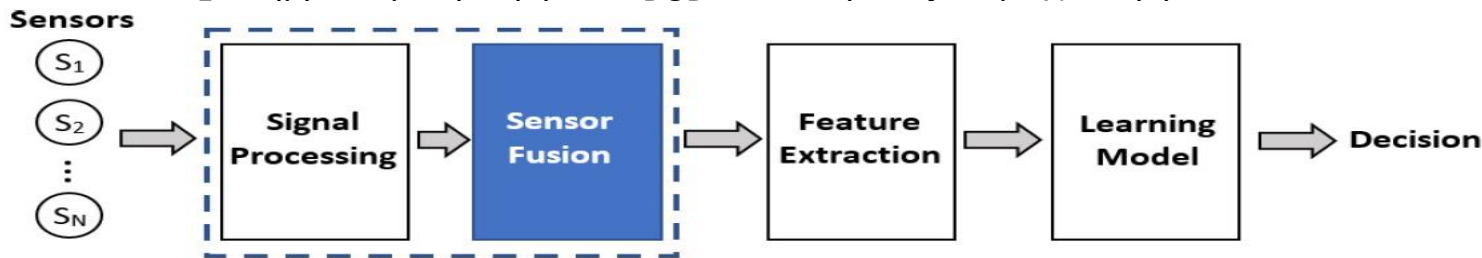
Latest research shows that AI models trained on early fusion data will provide better detection

Mid-level fusion (fusing features)

- Radar or lidar point cloud + vision object detection



Low-level fusion (*early fusion of the raw data*)



Challenges to Adoption of Mid & Low-Level Fusion

1. Huge raw data bandwidth (raw radar data 30 Gbps +) to process – *needs very high AI performance, but low cost, power effective for edge*
 - *Incumbents exceeding 20 TOPs: e.g. QCOM, TI, Ambarella, Renesas*
 - *Challenging start-ups exceeding 20 TOPs: e.g. Hailo, Blaize, Brainchip, EdgeCortex, untether, DeepX,*
2. Lack of early-fusion training data to train AI models and non-public

Challenges to Adoption to Mid & Low-Level Fusion

3. Need for a perception processing framework for calibrating, synchronizing different data sources
4. An easier (lower cost, time) means of collecting calibrated data sources in the field
5. An easier (lower cost, time) means to annotate fused data, auditing annotation and train an edge AI model based on this data

Anywhere where multi-mode perception sensing is required such as:

- Automotive (ADAS to AD, driver monitoring)
- Off-road (agriculture, construction, mining, material movement, defense)
- Factory, warehouse mobile robotics
- Drones (autonomy without pilot or GNSS)
- Security/surveillance
- Etc...

Picks & Shovels: Positioned for Edge Fusion Perception

Semiconductor

- Incumbents exceeding 20 TOPs: e.g.



- Challenger start-ups exceeding 20 TOPs: e.g. Tens Torrents, SiMa.ai, Rebellions,



Picks & Shovels: Positioned for Edge Fusion Perception

Edge AI Fusion Perception Frameworks - *very few*



PHANTOM AI



D3 Engineering

AI Models Optimized for the Edge - focus primarily on vision only, not fusion



EDGE IMPULSE



roboflow

NotaAI



alwaysAI

viso.ai

CLIKΛ.

embed

Data Annotation Tools - focus primarily on image and video annotation



LabelOps



CrowdAI



SuperAnnotate

viso.ai



alwaysAI



deepomatic

sama



Au-Zone
Technologies Inc.

1. Perception based on data fusion yields superior perception
2. Challenges of “early fusion” are being overcome
3. Fusion will move this decade from incumbent “late fusion” designs to “early fusion” implementations
4. Opportunities exist to differentiate throughout the value-chain to address the demands of early fusion

[Forbes 2Oct 2023: The 10 Biggest Generative AI Trends For 2024](#)

GlobalData Patent Analytics: [Key players in radar camera fusion](#)

Junhyuk Hyun, Yonsei University Korea, Computational Intelligence Lab

GlobalData's report on [Artificial Intelligence in Automotive: Radar Camera Fusion](#)

[IEEE Transactions on Intelligent Vehicles \(Volume: 9, Issue: 1, January 2024\) : Radar-Camera Fusion for Object Detection & Semantic Segmentation in Autonomous Driving: A Comprehensive Review](#)