How Microcontrollers help GPUs in Autonomous Drive

GTC 2017
Munich, 2017-10-12

Hans Adlkofer, VP Automotive System department
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<td>Main Safety concepts</td>
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<td>Sensor Fusion architecture and functionalities partitioning</td>
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<td>Key Safety Challenges and proposals</td>
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High Dependability

All requirements must be addressed as a whole

Continuity of correct service

- Reliability
- Maintainability
- Security
- Safety
- Availability

- Designed to undergo modifications and repairs
- Recognize hazards to achieve an acceptable level of risk against thief and hackers
- Recognize hazards to achieve an acceptable level of risk against faults
- Readiness for correct service
- Dependability
Some Main Safety Concepts: Safe Computing platform

**Hardware (Design Flow ISO 26262)**

- Lockstep Core, Built-In Self Test, Safety Management Unit, ...

**Safety Measures**

Protection against...

**Failure cause**

- Transient (Particle)
- Systematic (common causes: clock, supply, temperature, ...)

**Safe Computing Platform!!**

**Software (Design Flow ISO 26262)**

If SW not deterministic?

- SOTIF (Safety of the Intended Functionality)
Safety Partitioning between HW and SW

Strong Hardware Safety Support
(Self-test, Lock-step, ...)

Small & Fast SW Development/Test

VS.

Low Hardware Safety Support

Bigger & Longer Development of SW

Safety performance

ASIL-D ISO26262
Availability & Reliability

**Temperature**

**Fast Boot/Reboot**

**Design Rules**

**MCU is First in operation...and “Last to survive”**
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AD Compute Data Flow and Functionalities

Sense
- Lidar
- Radar
- Ultrasonic
- Camera
- GPS
- V2X
- Other Vehicle Sensors (ex: Position, Angle, Pressure)

Compute
- Perception
  - Sensor Fusion
  - Localization
  - Environment Model
- Trajectory selection
  - Vehicle Dynamics Model
  - Collision Avoidance
  - Actuation
- Path scenarios
  - Trajectory Planning
  - Behaviors
  - Motion Planning

Actuate
- Transmission
- Engine
- Braking
- Steering
Typical AD System Block Diagram for SAE L3+ (2020-2022)

Functionality
- Fusion and decision making
- AI-based perception
- Advanced sensor fusion
- Safety manager
- Security manager
- Vehicle gateway
- Black-box data recording

Compute Performance
- Number Cruncher(s)
  - 25+ TeraOps
- Safety Controller (eg: AURIX™)
  - >2K DMIPS (Real-time)
  - ASIL-D

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Functionality
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AD Compute Latencies

<table>
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<tr>
<th>Layer</th>
<th>Main Function</th>
<th>Typical Latency</th>
<th>Compute Workload</th>
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<tbody>
<tr>
<td>1</td>
<td>Simple Sensor Processing + Vehicle Dynamics + &quot;reflex&quot; reaction</td>
<td>0.01s to 0.1s</td>
<td>Low (Real-time)</td>
</tr>
<tr>
<td>2</td>
<td>Object Sensor Fusion + Collision Avoidance</td>
<td>0.1s to 1.0s</td>
<td>Medium</td>
</tr>
<tr>
<td>3</td>
<td>Advanced Sensor Fusion + Localization + Planning</td>
<td>Over 1.0s</td>
<td>High</td>
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Fail-Operational and low-latency Architectures

Performance, Power Budget, and Software Re-use Will Drive Architecture

**Symmetric**

- ADAS/AD
- Sensor Set #1,2
- Primary Compute (PC)
- Secondary Compute (SC)
- Supply source #1
- Supply source #2
- Bus 1
- Bus 2

**Attributes:**
- Higher cost
- Higher power consumption
- Full functionality in case of failure

**Asymmetric**

- ADAS/AD
- Sensor Set #1
- Sensor Set #2
- Switch #1
- Switch #2
- Primary Compute (PC)
- Secondary Compute (SC)
- Bus 1
- Bus 2
- Supply source #1
- Supply source #2

**Attributes:**
- Lower cost
- Lower power consumption
- Limited functionality in case of failure

**PC:** High Computation ("Number Cruncher"/GPU)

**SC:** Object-level Fusion / ASIL-D Controller
Cyber security: no Safety without Security!

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MCU key advantages
- Compact code (fast secure boot)
- Embedded Flash (key storage)

Replaced/Compromised Sensor
→ No integrity/quality of information
  
  Sensor Secure Boot
  Sensor + Message authentication

 Trojan, DoS, ...
→ Loss of control, increased latency, ...
  
  Component Fast Secure Boot
  Message Authentication
**Agenda**

| 1 | Main Safety concepts |
| 2 | Sensor Fusion architecture and functionalities partitioning |
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| 4 | Summary |
**Summary**

**Benefits of Microcontroller for AD**

- Sustain harsh environment for **High Availability & Reliability**
- Compact code size in embedded Flash for **high security level and fast secure boot**
- HW Safe Compute Platform for **ASIL-D safety critical** decision in AD
- Embedded legacy peripherals as the **secure Gateway** to the backbone

**Trend in Microcontroller for AD**

- Higher ASIL-D performance to **add more safety functionalities**
- Higher Performance to **back-up functionalities** of the Number Crunchers/GPU in case of failure
- Higher-speed Connectivity to **manage more complex data and decrease latency** in the decision process