ENHANCING ENDPOINT INTELLIGENCE
With Embedded Artificial Intelligence (e-AI) from Renesas

Real-time Intelligence without Cloud Lag

Artificial Intelligence is rapidly driving growth in the information technology (IT) and operational technology (OT) domains. For years, Renesas has been a leader in OT endpoint applications with microprocessor and microcontroller solutions. Leveraging that experience, Renesas’ e-AI solutions are enhancing OT-based systems and products that we use around us every day by placing AI where it matters the most – at the endpoint – while decoupling dependency on the Cloud for real-time decisions and real-time action. Additionally, Renesas will expand e-AI application possibilities with the use of its exclusive extreme low-power process technology, Silicon On Thin Buried Oxide or SOTB™, to enable batteryless solutions powered only by harvested ambient energy. Think of the possibilities.

Enhanced by e-AI
- Endpoint real-time inference
- Cognition
- Endpoint learning

Expanded by Extreme Low Power
- SOTB™ batteryless system
- Maintenance free
- New energy sources

Endpoint Intelligence Innovation

IT
Information Technology

OT
Operational Technology

AI Grows Entire Market

Renesas’ Proven Operational Technology
- Real-time system
- Control technology
- Safety and robustness
e-AI Capability Advancements

- Renesas is evolving e-AI. From MCU to MPU and then to Embedded-AI MPU, AI performance improves with each step
- Exclusive Dynamically Reconfigurable Processor (DRP) technology accelerates image processing, object recognition, AI, and cognitive decision making

- Each advance in DRP (see below) brings 10 times the computing power of the previous generation

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**e-AI: Local Real-time AI by Inference**

- Traditional statistical AI applications execute completely in the Cloud
- Real-time applications cannot tolerate cloud lag at the endpoint
- e-AI takes immediate action locally through inference from cloud-trained AI neural networks

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**e-AI Capability**

- 2018: Endpoint Inference on MCU/MPU
- 2019: Real-time Image Processing by DRP
- 2020: Real-time Cognition by DRP
- 2021:
  - Further improvement of power performance by next-generation DRP-AI
  - Solution released July 2017
- 2022:
  - Learning & Inference in Cloud
  - Pre- or One-time Training
  - RZ/A2M product release October 2018
- 2023:
  - Learning in Cloud
  - No Cloud Lag
  - RZ/V2M product release May 2020

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**Cloud**

**Edge**

**Endpoint**

**IT**

**OT**

**Information Technology**

**Operational Technology**

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**Statistical Application**

**Real-time Application**

**Learning in Cloud**

**Pre- or One-time Training**

**Real-time action**

**No Cloud Lag**

**AI Inference at Endpoint**
**Performance and Flexibility**

- Ideal for Human Machine Interface (HMI)
  - Multiple video output standards
  - Multiple graphics engines
- Accelerate Image Recognition
  - Boost image processing x10 with DRP
  - MIPI CSI camera interface
- Advanced Security
  - Secure boot, communication, and update

**Software Package for AI+HMI**

- RTOS, drivers, and middleware
- DRP tools, libraries, and application layer
- Smart configurator for SDK
- Quick and efficient camera/display graphical configuration with real-time feedback
- Seamless integration with TES Guiliani GUI framework

**RZ/A2M Evaluation Platform**

- Supports DRP evaluation
- MIPI Camera Module (MIPI CSI)
- HyperMCP with HyperFlash™ and HyperRAM™
- RGB conversion board for HDMI display
- 2ch Ethernet communication
- Other peripheral functions, such as SDHI and USB

Kit Part Number: RTK7921053S00000BE

Learn more: https://www.renesas.com/RZA2M

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**Dynamically Reconfigurable Processor (DRP)**

- DRP
  - Dynamically reconfigurable acceleration hardware
  - Offloads burden of specialized tasks from main processor
- Extreme Efficiency
  - Higher performance and lower power than use of CPU, GP-GPU, DSP, or FPGAs
- Flexibility
  - It is possible to execute different tasks by switching DRP libraries, even while the MPU is operating
  - Continuous new functions available to previously shipped products extend product life
- Acceleration
  - Image processing: edge detection, gray level, feature extraction, and more
  - Next: AI acceleration

**Accelerate Video Processing with DRP**

<table>
<thead>
<tr>
<th>Process</th>
<th>Execution Time (ms)</th>
<th>DRP</th>
<th>CPU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canny Edge Detection</td>
<td>9.3</td>
<td>138.3*</td>
<td>138.3*</td>
</tr>
<tr>
<td>Harris Corner Detection</td>
<td>13.8</td>
<td>294.1*</td>
<td>294.1*</td>
</tr>
<tr>
<td>QR Marker Detection</td>
<td>31.3</td>
<td>223.0**</td>
<td>223.0**</td>
</tr>
</tbody>
</table>

* CPU: Using OpenCV (cv::medianBlur+cv::Canny)
** QR Marker detection: ZBar (cv::medianBlur+Zbar detection)

**RZ/A2M Microprocessor with DRP – Hardware Acceleration for e-AI**

**RZ/A2M Microprocessor Block Diagram**

- System
  - 16 × DMAC
  - Interrupt Controller
  - PLI/SSOC
  - On-chip Debug
  - Arm CoreSight
  - Standby (Deep/Sleep/Deep/Module)
  - GTP (Option)
  - (One Time Programmable)
- Memory
  - SRAM: 4 MB
  - L2 Cache: 128 KB
- Timers
  - 2 × 32-bit OSTM
  - 1 × 32-bit MTU3
  - 8 × 16-bit MTU3
  - 8 × 32-bit PWM
  - 1 × WDT
  - 1 × RTC
- Analog
  - 8 × 12-bit ADC
- Security (Option)
  - Secure Boot
  - Device Unique ID
  - Crypto Engine
  - JTAG Disable
  - TINQ
  - Arm TrustZone
- DRP
  - Custom Functions
- CPU
  - Arm Cortex®-A9
  - 528 MHz (1320 DMIPS)
  - 1.20V (Core), 3.3V (I/O), 1.8V (I/O)
  - NEON
- Interfaces
  - 4 × FC
  - 2 × SCI
  - 5 × SDI (8/10)
  - 3 × RSPI
  - 2 × CAN-FD
  - 2 × Ethernet MAC (10/100M: IEEE1588)
  - 1 × I2DA
  - 1 × SPIF
  - 4 × SSI (IFS)
  - 1 × BSC (Ext. Bus I/F)
  - 1 × HyperFlash/RAM (128 Mif ST, 8-bit)
  - 1 × SPI Multi I/O (DTR)
  - (DSP, HyperFlash)
  - 1 × NAND (SMI6, 16-bit)
  - 2 × USB2.0 Host
  - 2 × SDHI (UHS-I/MMC)
  - 2 × GPIO

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**RZ/A2M Awarded 2018 Product of The Year by Electronic Products**
e-AI Use Cases

e-AI Failure Prediction for Motors

- Detects previously invisible faults in real time by minutely analyzing oscillation waveforms from motors through current, vibration, or sound
- Predicts failure before it occurs to enable early warning
- Improves service quality, avoids downtime, and reduces maintenance costs

e-AI Multimodal Biometrics Authentication by Image Recognition

Biometrics Information

Authentication Data

- Match
- Match
- Match
- Detect

Airports
Passport

Cashless
ID Card

Office Entry Systems
ID Card

Mobile Systems, Body-worn
Criminal Photo

e-AI Deployed at Renesas Semiconductor Factory

Smart Factory moves from Preventive Maintenance to Predictive Maintenance

- Successfully detected defective wafers using e-AI, same as human experts could do
- Reduced false alarms from 50 incidents per month to ZERO
- Anomaly detection rate improved by 6x
- Reduced engineering resources required to respond
- Eliminated requirement to set statistical thresholds

Renesas installed over 150 AI units into one of its own semiconductor factories, with 3,000 more AI units on the way

Learn more about Renesas e-AI solutions at:
https://www.renesas.com/e-ai