Smart, Safe, and Scalable: Designing the Next Generation of Robotics

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Executive Summary

The robotics industry is moving from task-specific machines to intelligent, adaptive systems that operate across diverse sectors from logistics and manufacturing to healthcare and retail. Robots are now collaborating with humans on factory floors, functioning autonomously in the field, and enhancing human capabilities in areas like rehabilitation and mobility.

This evolution brings with it a range of technical challenges, such as the need to balance performance with power efficiency and thermal constraints, ensure real-time responsiveness with minimal latency, and maintain robust connectivity and security throughout the system.

These challenges are being addressed through advancements in AI, edge computing, and sensor fusion, enabling machines to perceive, decide, and act with increasing autonomy. A key trend is the shift from component-level optimization to system-level integration, where the synergy between compute, motor control, sensing, connectivity, and power management defines the success of a robotics solution.

Renesas is at the forefront of this integration. Its portfolio empowers developers to accelerate time-to-market while meeting stringent performance, size, and efficiency requirements. A prime example is the Dexterous Hand, a system that demonstrates how edge AI, real-time control, precision actuation, and efficient power delivery can work in harmony for advanced industrial robotics.

To further streamline development, Renesas offers tools like the AI Model Deployer, lowering barriers to AI integration and enabling faster prototyping and deployment.

The advanced robotics market is expected to grow significantly from $53.74 billion in 2025 to over $280 billion by 2034, with an average annual growth rate of 20.13%. This white paper outlines how to stay ahead in a rapidly evolving landscape through intelligent system design and integrated development tools.

Content

Introduction

The robotics industry is at a pivotal moment. No longer confined to isolated industrial cells, robots are entering dynamic, unstructured environments from warehouse automation and last-mile delivery to service robots that interact with humans. This transformation is being driven by advances in AI, edge computing, and sensor fusion, enabling machines to perceive, decide, and act with increasing autonomy.

As robots move from predictable factory floors to real-world settings, the demands on their systems grow exponentially. They must interpret complex environments, respond to unpredictable stimuli, and operate safely alongside people, all while coordinating perception, control, and communication across distributed subsystems, managing energy constraints, and maintaining awareness of their position and surroundings in real time. This calls for a new class of systems: ones that seamlessly integrate real-time motor control with intelligent perception, autonomous decision-making, and strict safety compliance.

But this convergence introduces new challenges:

- How can developers integrate AI-based vision and gesture recognition without offloading to external accelerators?
- How can teams leverage ROS (Robot Operating System) 2 and Linux while maintaining low-latency real-time motor control on the same processor?
- Can teams meet functional safety standards like IEC 61508 without increasing development complexity?

These questions reflect a broader shift in robotics design from component-level optimization to system-level integration.

Robotics Landscape

The robotics industry is experiencing tremendous growth, driven by automation demands, workforce shifts, and breakthroughs in AI and sensing. Across sectors from logistics and manufacturing to healthcare and retail, robots are evolving from specialized machines to intelligent, adaptive systems, some collaborating closely with humans on factory floors, others operating autonomously in the field, and many augmenting human abilities in applications like rehabilitation and mobility.

The idea of what a robot is and what it should do is being completely rethought.

- **What Society and Warehouses Expect from Robotics**

As aging populations strain healthcare and caregiving systems in developed countries, robots are being embraced not just as labor-saving tools but as trusted assistants and even companions.

The service robotics market including home assistants, hospitality bots, and cleaning systems is expected to more than double by 2030. The humanoid robot category, fueled by breakthroughs in edge AI, mobility, and perception, is set to grow at a staggering little less than 50% every year.

At the same time, industries like logistics, retail, and services are adopting an automation-first mindset to meet rising expectations for speed, availability, and personalization. Whether assisting the elderly, restocking shelves, or navigating public environments, robots are moving from novelty to normalcy.

The autonomous mobile robot (AMR) segment, driven by logistics and warehousing applications, is forecasted to grow around 15.3% every year from now to 2030 at least.

- **How Well Robots Are Expected to Perform**

In real-world conditions, robots must continuously sense, interpret, and respond on the fly. This need is fueling the shift toward edge AI, where data is processed locally on the robot instead of relying on cloud infrastructure. By enabling faster decision-making, enhanced privacy, and greater autonomy, this architecture is rapidly becoming the norm.

Connectivity in robotics enables real-time, resilient communication across all system layers, from sensors to fleet coordination. Extending this down to motor drives allows robots to detect anomalies, report usage, and predict faults. This transforms connectivity into a health-monitoring backbone, making robots not only responsive but also self-aware and reliable over time.

As robots become more mobile, compact, and distributed, innovation at the system level is paramount. New approaches in motor control (smaller, quieter, more precise drives), power delivery (onboard energy management, fast charging), and semiconductor materials (e.g., Wide Bandgap [WBG] for power efficiency) are opening new frontiers. Chip embedding, modular platforms, and even wireless charging are shaping the next generation of compact robotic systems.

Functional safety is also essential as robots move into shared spaces like factories, hospitals, and homes. Robots must operate reliably and fail safely. Standards like IEC 60730 and IEC 61508 define fault tolerance and system integrity, requiring built-in tests, redundancy, and separation of safety functions. Certified tools help developers meet these standards without added complexity. In automation and mobile robotics, SIL3 compliance ensures high safety integrity, often using TÜV-certified libraries and reference designs. Advanced architectures even allow safety and non-safety domains to coexist on the same chip, reducing hardware needs. Safety is no longer optional, it's foundational.

Core Challenges in Modern Robotics Development

Despite strong market momentum, building intelligent, autonomous robots remains a complex endeavor. As robots transition from controlled settings into dynamic environments, development teams face a unique blend of technical and strategic challenges.

Performance vs Power/Thermal	Real-Time Responsiveness	Connectivity & Security	Cost and Scalability	Regulatory Complexity
Run AI without overheating Balance high-throughput workloads with tight energy and thermal constraints	**Low Latency** Ensure real-time behavior across motion, vision, and safety subsystems	**Stay Connected, stay secure** Enable fast communication while protecting against cyber threats	**Scale smart, build lean** Scalable, low-cost systems enable broader market reach	**Design for Compliance** Meet diverse safety and network standards across global markets

- **Balancing Performance, Power Efficiency, and Thermal Constraints:** Modern robots must run complex AI workloads, perform sensor fusion, and make real-time decisions, all within tight thermal and power budgets. This is especially true in mobile or battery-powered platforms, where high performance can quickly translate into overheating or battery drain. Designing systems that maintain computational throughput without exceeding energy or thermal limits remains a critical hurdle.

- **Achieving Real-Time Responsiveness and Low Latency**: Applications that require collaborative robotics, autonomous navigation, and object manipulation demand rapid response to changing environments. From motor control to safety loops and visual processing, each subsystem must react with precision to dynamic environments leaving no room for software jitter or resource contention.

- **Managing Connectivity and Security:** As robots connect to enterprise networks, the cloud, and other robots, they become part of larger digital ecosystems. But with connectivity comes vulnerability. Teams must ensure data privacy, secure firmware updates, and protection against cyber threats, while still delivering low-latency performance. To support these requirements, systems must be designed in an "always-connected" mode with high robustness, ensuring that communication remains reliable even under harsh conditions or network disruptions.

- **Controlling System Cost and Scalability:** Both service and consumer-grade robot markets exhibit extreme price sensitivity because they must compete directly against existing solutions. The price pressure creates a fundamental design challenge, manufacturers must carefully balance system performance with cost-efficiency to achieve commercial viability, often requiring innovative engineering solutions that deliver essential functionality while eliminating non-critical features. Scalable modular architectures that can support multiple product tiers from basic entry-level units to feature-rich premium systems have become increasingly valuable, allowing companies to address diverse market segments while leveraging shared components and development costs across their product lines.

- **Navigating an Evolving Regulatory Landscape:** The robotics space is moving faster than the regulatory framework can keep up. Engineers must navigate fragmented and shifting safety standards, compliance requirements, and operational restrictions that vary across regions. Lack of standardized guidelines can slow deployment and increase development risks.

Enabling Intelligence at the Edge

While the challenges above span performance, responsiveness, security, cost, and compliance, they share a common thread: each is amplified by the growing intelligence required at the edge. Consider a delivery robot

navigating busy sidewalks, it cannot afford to wait for cloud-based decisions when network connectivity drops in

an urban dead zone. The robot must perceive the obstacle, calculate multiple trajectory options, and execute evasive maneuvers within milliseconds, all while maintaining package security and route efficiency. This demands a fundamentally different design philosophy: embedding advanced AI capabilities directly into the robot, close to its sensors and actuators, while ensuring hardware and software remain tightly synchronized, power-efficient, and thermally optimized. A delivery robot equipped with edge-based computer vision can instantly recognize and classify objects, predict pedestrian movements, and adapt its navigation strategy without relying on distant servers or risking communication delays.

Edge computing thus becomes more than a technological trend; it has become the foundation that enables robots to overcome obstacles such as latency, responsiveness, and operational resilience. By moving intelligence closer to sensors and actuators, developers unlock the ability for robots to perceive, decide, and act almost instantaneously, whether it's a delivery robot navigating crowded sidewalks or a collaborative arm adapting to a human co-worker's movement. Yet while the hardware for high-performance edge AI is already available, the real constraint lies in managing battery life, thermal load, and form-factor trade-offs. Every additional watt consumed by AI inference shortens runtime, complicates power management, and places pressure on system size and weight. For robotics teams, the question is no longer if edge AI can be deployed, but how can it be done efficiently enough to sustain safe, autonomous operation over hours of continuous use.

Why Edge AI Matters in Robotics

Let's see why Edge AI has become indispensable:

- **Fast Perception → Real-Time Action**
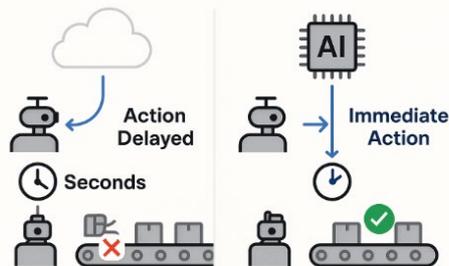
Edge AI processes high-volume sensor data such as camera streams, radar signals, and Inertial Measurement Unit (IMU) readings directly on the device, reducing latency and enabling rapid reactions in dynamic environments. If this data were sent to the cloud, response times would be too slow for real-time decision-making. For example, factory inspection robots equipped with high-resolution cameras can detect defects on

conveyor belts in milliseconds by analyzing images locally, allowing them to halt production immediately and prevent faulty products from reaching customers.

- **Resilient Autonomy → Offline Operation**
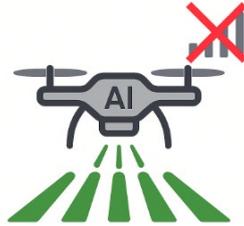
Edge AI enables robots to operate independently of network availability by running perception and decision-making locally. In the field, an agricultural drone can analyze multispectral camera feeds to assess crop health and detect pests, even when cellular coverage is poor. This offline autonomy removes cloud round-trips, prevents stalled operations, and keeps missions running safely and efficiently.

- **Sensitive Environments → Data Privacy**
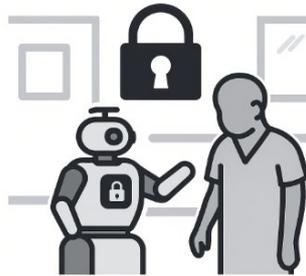
Data privacy needs to be maintained, keeping sensitive operational or user data on-device rather than transmitting externally. Robots in healthcare and other sensitive environments process patient images, voice commands, and health metrics locally, ensuring privacy and compliance with regulations. For example, a hospital robot uses facial and voice recognition to assist patients and monitor safety, all while keeping data securely onboard for real-time, confidential operation.

- **Long Runtime → Power Efficiency**
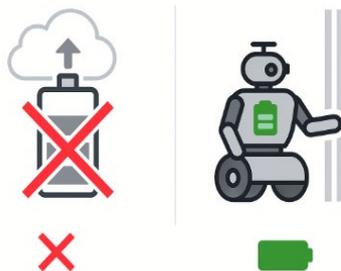
Transmitting large data streams to the cloud drains battery life, making power efficiency critical for robots that operate for hours without interruption. Edge AI minimizes this by processing navigation and sensor data locally,

reducing energy consumption and extending operational time. For example, warehouse robots that handle camera and LiDAR data on-device conserve power, avoid constant uploads, and maximize runtime between charges.

Essential Building Blocks for Robotics Systems
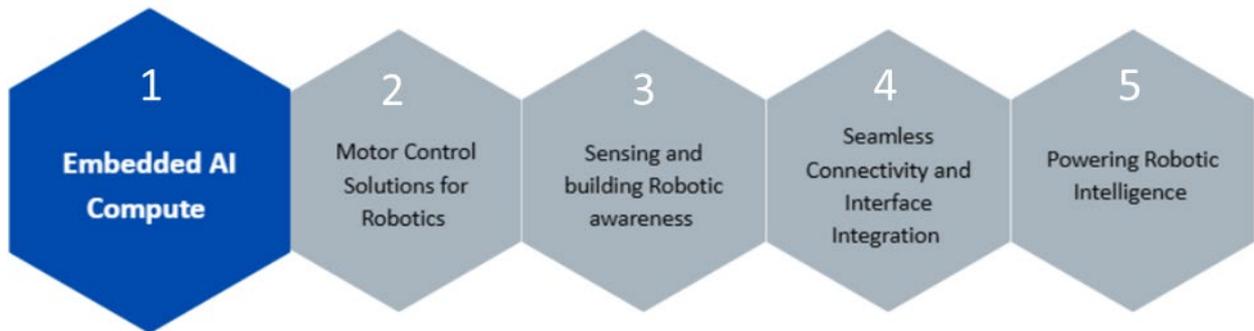
1. Edge AI Compute for Robotic Systems

Robotic systems often operate in ever-changing environments where latency, power, and size constraints are critical. Traditional GPU-based or cloud-first AI approaches often struggle to meet these constraints due to high power consumption, thermal challenges, and reliance on network connectivity. To overcome these limitations, modern robotics platforms increasingly adopt edge AI architectures that deliver deterministic inference and real-time control directly on the device.

One approach gaining traction is the use of heterogeneous processing architectures that combine general-purpose CPUs, real-time cores, and specialized AI accelerators. This integration enables robots to execute tasks such as path planning, visual odometry, and anomaly detection without cloud dependency, reducing latency and improving reliability in bandwidth-constrained environments. Additionally, tight coupling between perception and actuation layers minimizes system complexity and shortens development cycles by avoiding fragmented compute architectures.

- **AI Inference with Real-Time Control:** High-performance edge processors now integrate vision AI acceleration and deterministic motor control within a single platform. For example, some architectures combine multi-core application processors for AI inference, real-time cores for motion control, and dedicated AI accelerators for vision tasks such as Simultaneous Localization and Mapping (SLAM) and obstacle detection. The RZ/V2H MPU exemplifies this approach by integrating DRP-AI accelerators with real-time cores, enabling synchronized perception and actuation under strict thermal and power constraints.

- **Scalable AI Performance for Compact Edge Systems:** Not all robotics applications require maximum compute density. For cost and space-sensitive platforms, energy-efficient processors with integrated AI accelerators can deliver 1 TOPS/W-class performance, enabling lightweight models like Tiny YOLOv2 for gesture recognition or anomaly detection. Features such as onboard image signal processing, camera interfaces, and display outputs further simplify system design for robots with integrated vision and HMI requirements. Solutions such as the RZ/V2L demonstrate how this balance can be achieved, combining AI acceleration with onboard ISP and camera interfaces to simplify vision-enabled robotics design.

- **Visual Perception for Intelligent Systems:** Emerging solutions also target ultra-compact robotics systems where power budgets are below 2 W. These platforms leverage AI accelerators optimized for

high TOPS/W efficiency, supporting workloads like object detection and pose estimation without active cooling. Multi-camera support and virtual channeling enhance depth perception and situational awareness, critical for applications such as stereo-vision service robots and in-cabin monitoring systems. The RZ/V2N, for instance, illustrates how multi-camera support and virtual channeling can enhance depth perception and situational awareness in space-constrained robotics applications.
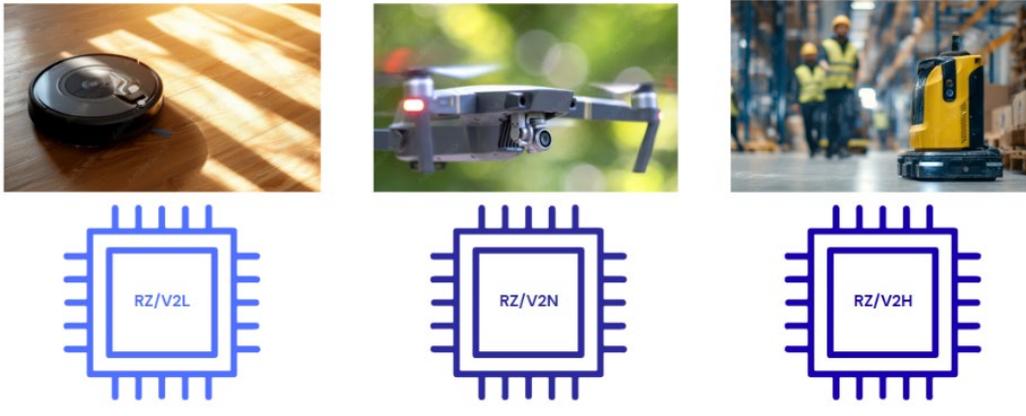
By leveraging heterogeneous compute architectures and energy-efficient AI acceleration, robotics developers can achieve real-time perception and control at the edge, principles exemplified by solutions like the RZ/V family, which demonstrate how these concepts translate into practical, scalable designs for more intelligent, perceptive, and autonomous systems.
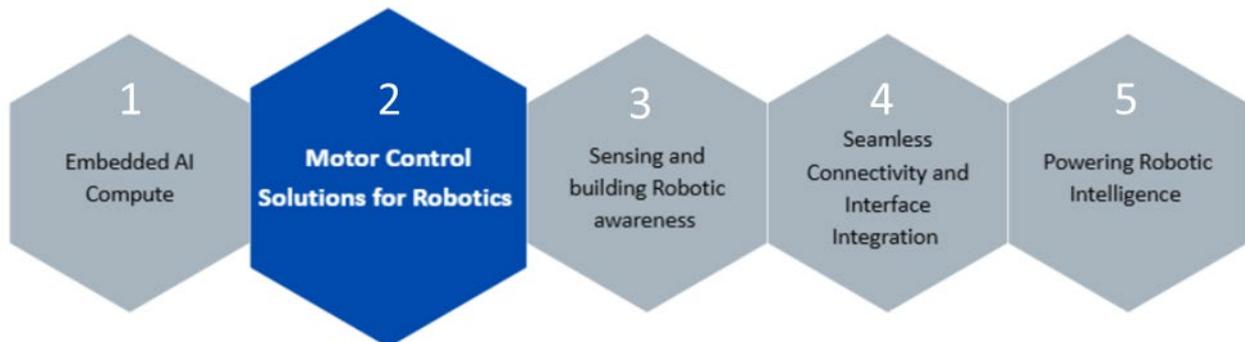
2. Motor Control Solutions for Robotics

While edge AI computing empowers robots to perceive and understand their surroundings, true autonomy demands responsive physical interaction. Translating decisions into coordinated physical actions is critical for tasks ranging from industrial automation to service robotics.

- **Precision in Compact Robotic Joints:** Small robots and actuators often face tight size and power constraints, yet demand smooth, accurate motion. Modern MCUs designed for motor control integrate features such as PWM timers, A/D converters, and trigonometric function accelerators in compact packages, enabling efficient control loops without external components. For example, RA4T1 MCU illustrates this by combining motor control peripherals with connectivity options such as CAN FD and SPI, supporting space-constrained platforms like miniature arms, grippers, and service robots.

- **Coordinated Multi-Axis Manipulation:** Industrial and collaborative arms require highly synchronized movement across multiple joints, often with sub-millimeter accuracy. Advanced MCUs now support dual-inverter vector control, resolver feedback, and real-time communication protocols to achieve this. Solutions

such as the RX24T and RX72M demonstrate how integrated EtherCAT® and multi-axis control capabilities can reduce BOM complexity and improve interoperability in SCARA (Selective Compliance Assembly Robot Arm) and articulated robots.

- **High-Speed, Synchronized Motion in Industrial Robotics:** In high-throughput environments like assembly lines, robots must execute precise movements at very high frequencies while maintaining real-time network synchronization. Some MPUs fuse Linux-capable application cores with real-time cores for ultra-low-latency motor loops, enabling control of multiple axes within microseconds. The RZ/T2H, for instance, consolidates application processing, real-time control, and industrial networking (EtherCAT®, PROFINET®, TSN) into a single device, reducing footprint and integration time for complex robotic systems.

- **Feedback Accuracy in Harsh Environments:** Dust, vibration, and oil can degrade optical encoders, threatening positioning accuracy and long-term reliability. For robots operating in outdoor, industrial, and heavy-duty environments, developers must prioritize feedback systems that maintain precision under these conditions. While selecting resolver-based feedback solutions, engineers should consider factors such as temperature range, vibration tolerance, electromagnetic immunity, and fault detection capabilities. These attributes ensure not only accuracy but also resilience and reduced maintenance costs over the robot's lifecycle, critical for applications like autonomous construction equipment, agricultural robots, and factory automation in dusty or oily settings. One such RDC that incorporates these design principles is the RAA3064002GFP, which offers high-resolution angle conversion, integrated error correction, noise filtering, and fault detection features to maintain robust performance in harsh environments.

- **Integrated Servo Drive Control:** Developers of collaborative arms, and mobile robotic systems face the challenge of minimizing the footprint. With robots becoming more compact and power-dense, integrating multiple control and protection functions into a single device is an effective way to reduce board area and improve reliability. A few considerations for integrated servo design include programmability, high-voltage handling, current sensing accuracy, and fault protection. These attributes ensure precise torque and speed control while maintaining safety and efficiency in space-constrained designs. The SLG47115 HVPAK addresses these requirements, which combines a high-voltage H-bridge with programmable logic in a compact package. When paired with current-sensing amplifiers like the ISL28022, it enables closed-loop control and protection features without the need for multiple discrete components.
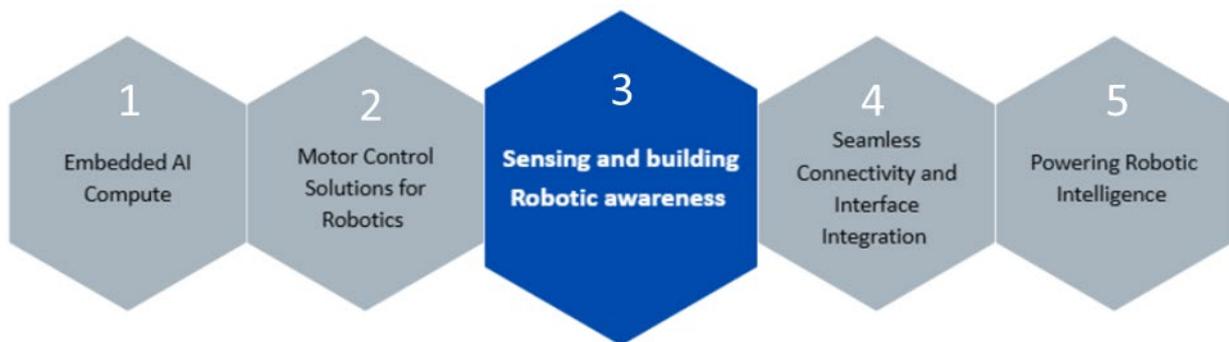

3. Sensing and building Robotic awareness

Compute and control enable robots to act, but true autonomy depends on accurate sensing to understand position, orientation, and environment. In robotic arms and manipulators, robust, contactless position feedback is essential, particularly in environments with dust, moisture, and electromagnetic interference, where traditional optical encoders can degrade over time.
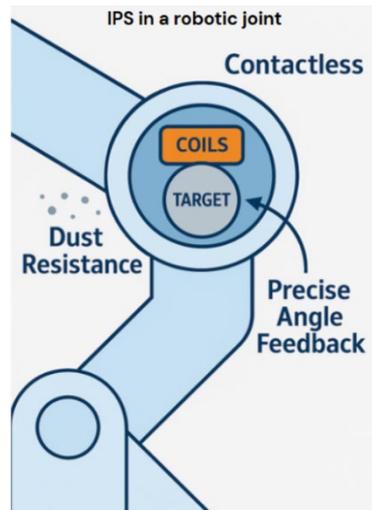
Inductive position sensors have become a preferred alternative, offering precise, reliable measurements without mechanical wear. These sensors are widely used for joint angle measurement and for ensuring repeatable alignment across multiple axes in industrial and medical/surgical robots.

This is implemented in the IPS2550 inductive position sensor, which delivers absolute rotor position measurement and IP-protected communication for long-term reliability.
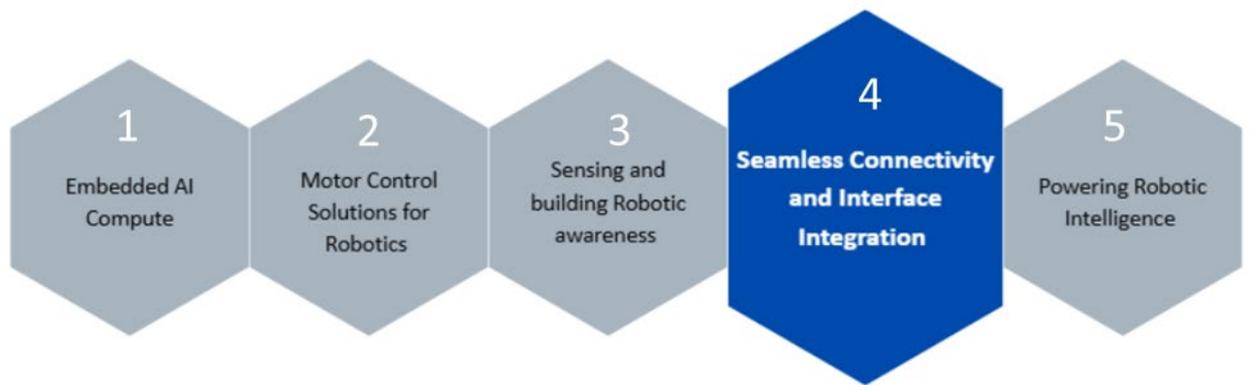
4. Seamless Connectivity and Interface Integration

Coordinating sensors, motors, user interfaces, and control units requires consistent, real-time communication across diverse topologies. Whether it's synchronizing multi-axis motion, enabling wireless updates, or establishing low-latency feedback loops, connectivity forms the backbone of robotic systems. This typically spans three critical layers:

- o Real-time wired communication for deterministic control and synchronized motion
- o Wireless communication for mobility, remote monitoring, and cloud integration
- o Proximity-based interfaces for secure configuration, maintenance, and access control

Deterministic Wired Links: Industrial robots often operate in electrically noisy environments, making robust wired protocols essential for real-time control. For short-distance communication between motor drives, sensors, and controllers, differential signaling standards like RS-485 are widely used because they provide low latency and strong immunity to electromagnetic interference (EMI). In addition to noise resilience, Electrostatic Discharge (ESD) protection is critical in these environments to prevent damage from electrostatic discharge during installation or maintenance. Components designed with high ESD tolerance and low-power operation help ensure long-term reliability in compact, EMI-sensitive robotic systems.

Wireless for Flexibility and Mobility: Wireless connectivity enables mobile robots, remote diagnostics, and cloud-based analytics. Bluetooth® Low Energy (BLE) is well-suited for operator interfaces or peripheral subsystems, while Wi-Fi provides the bandwidth needed for data-intensive tasks such as vision streaming or over-the-air (OTA) updates. Dual-mode solutions that combine Wi-Fi and BLE simplify integration for service robots that require both local and cloud connectivity.

Proximity Interfaces for Secure Access: NFC offers a convenient way to configure, authenticate, or maintain robots without physical connectors, ideal for environments where sealed enclosures or hygiene requirements make wired access impractical.

Location Awareness at Scale: As robotic systems scale, precise location tracking becomes essential for dynamic routing, collision avoidance, and task optimization. Bluetooth®-based RTLS solutions are gaining traction because they combine sub-meter accuracy, low power consumption, and scalability. Unlike traditional systems that require complex synchronization or dense infrastructure, modern RTLS platforms can track thousands of assets with fewer locators, reducing deployment costs. For example, in a logistics facility, high-refresh-rate RTLS enables real-time tracking of autonomous mobile robots (AMRs) even in non-line-of-sight conditions. This allows fleet management systems to reroute robots dynamically, prevent collisions, and coordinate multi-robot tasks such as collaborative picking, all while minimizing infrastructure overhead. Solutions like Asset Tracking & Locationing at Scale (ATLAS illustrate how Bluetooth-based RTLS can achieve <50 cm accuracy and scale efficiently for large AMR fleets.

High-Throughput Local Networking: As robots take on more complex tasks, high-speed wireless links become essential for multi-robot coordination and cloud integration. Emerging Wi-Fi standards (Wi-Fi 6/6E) offer the throughput and efficiency needed for vision data and real-time collaboration without compromising energy efficiency.
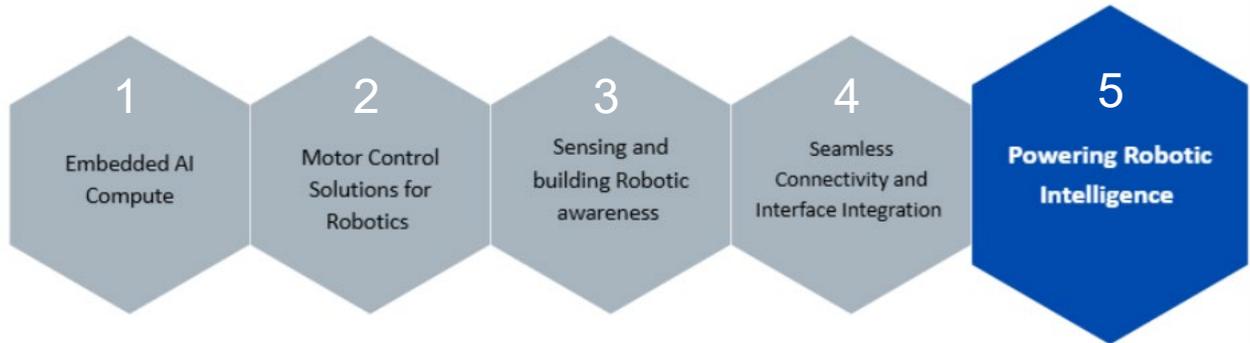
5. Powering Robotic Intelligence

One of the hardest problems in robotics is its energy discipline. Every thermal spike in a motor driver constrains how aggressively AI can run. Power isn't a utility; it's the invisible governor of autonomy.

Designing for this reality means treating power as a system-level strategy, not an afterthought. That strategy must:

- o Allocate energy dynamically across compute, sensing, and actuation
- o Deliver multiple voltage rails with minimal conversion loss
- o Shrink thermal footprints without sacrificing performance

Consider AMRs: they must sustain hours of operation while running vision pipelines, navigation stacks, and safety systems in real time. Advanced approaches such as integrated PMICs for heterogeneous compute and GaN-based power stages for high-efficiency motor control show how designers can achieve lighter, cooler, and more energy-efficient platforms without compromising capability.

The Dexterous Hand

While each robotics building block like compute, motor control, sensing, connectivity, and power can be evaluated in isolation, the true value emerges when they are architected as a cohesive system. In an effective design, AI compute doesn't just process vision data, it's synchronized with deterministic motor control loops; power delivery is optimized for peak loads without thermal penalties; connectivity protocols ensure seamless interaction with broader automation networks; and sensing modules feed real-time insights into decision-making engines. This systems level integration is where Renesas' portfolio shows its strength, enabling developers to go from concept to deployment faster while meeting performance, size, and efficiency targets.

To illustrate, let's look at a winning combination: Dexterous Hand. This system demonstrates how edge AI compute, real-time control, precision actuation, connectivity, and efficient power management can work in harmony for advanced industrial robotics applications.

The Dexterous Hand is engineered for precise and natural manipulation, featuring six pneumatic cylinders to control five fingers, with auxiliary actuators enhancing articulation and flexibility. It incorporates an intuitive GUI that delivers real-time feedback, making the system accessible even to beginners. With versatile communication interfaces and seamless sensor integration, it adapts easily across prosthetics, industrial automation, and robotics research. To ensure interoperability, micro-ROS at the processor level bridges into ROS 2 via CAN FD, enabling the hand to integrate directly into larger automation frameworks with high-speed data exchange. A custom Python-based GUI running on Ubuntu further supports real-time monitoring, gesture visualization, and direct operator control.
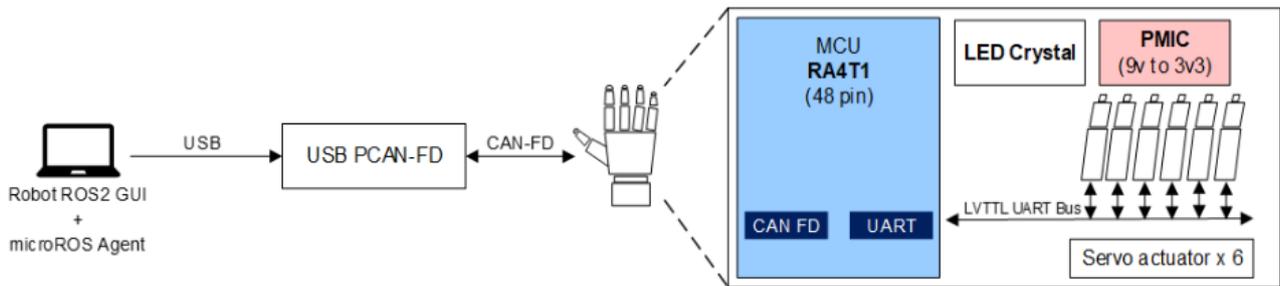
Building on this foundation, another implementation integrates AI vision to elevate responsiveness. Powered by the RZ/V2H MPU, it combines high-performance AI inference with ultra-reliable motor control. The MPU's DRP-AI3 accelerator enables real-time gesture recognition from camera input, detecting and interpreting over 20 distinct hand gestures, from grasp and pinch to thumbs up, and converting them instantly into coordinated movements. Each of the six pneumatic cylinders independently controls a finger or joint, delivering natural, low-latency motion for tasks like assembly, inspection or object-sorting. From a power perspective, the design follows an efficient chain that aligns with Renesas' power architecture best practices. 24V input is stepped down by a Buck regulator to 3.5V. This feeds the PMIC block, which provides the multiple regulated rails needed by the MPU and other peripheral components. This helps in minimizing conversion losses, reduce board space, and ensure a stable supply even under transient loads from AI processing and actuator control.
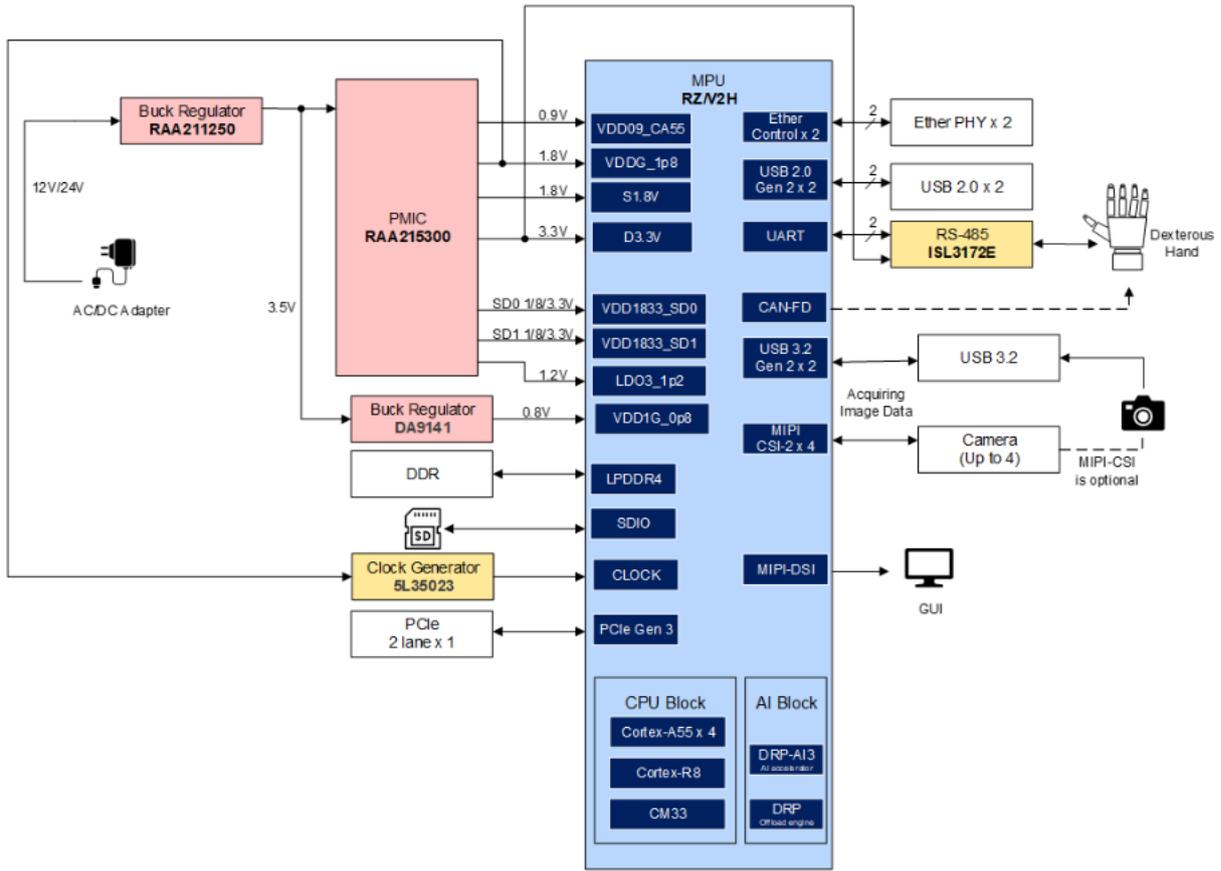
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The modular design supports extensive sensor integration, allowing for expansion into adaptive gripping, tactile feedback, or environmental awareness features. With its combination of high-precision actuation, AI-powered perception, the AI vision enhanced dexterous hand is more than a showcase, it's a proof point for how Renesas' portfolio enables the next generation of collaborative, intelligent, and responsive robotic systems.

Enabling Developers with AI Model Deployer

Building efficient edge AI for robotics is rarely about algorithms alone, it's about integration. Developers face a maze of challenges: model optimization, pruning, quantization, and mapping to hardware accelerators, all while meeting strict power and latency budgets.
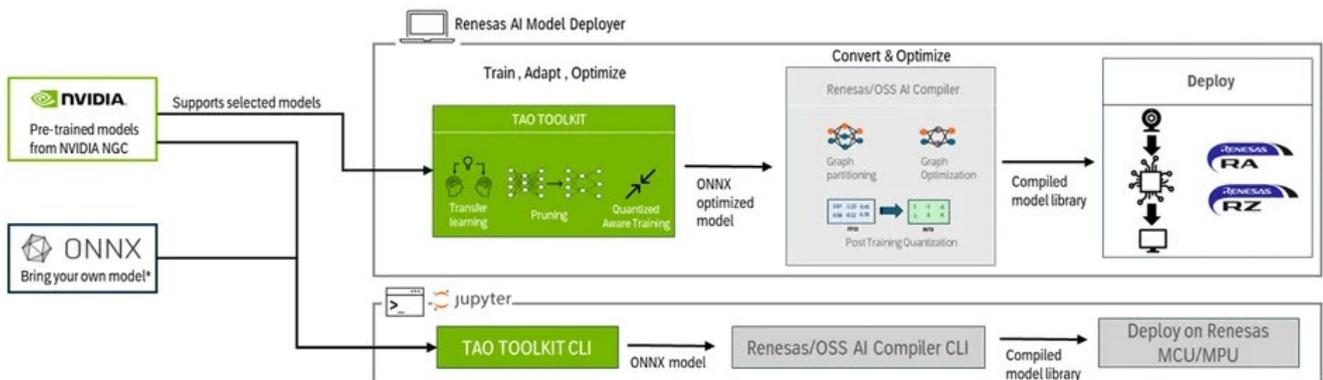
To lower these barriers, toolchains are emerging that combine model optimization, hardware acceleration, and intuitive workflows. One example is Renesas' AI Model Deployer, which bridges popular workflows such as NVIDIA's TAO Toolkit with embedded platforms like RZ/V2 MPUs and RA8 MCUs. By automating steps like quantization and conversion, these solutions can shrink deployment timelines from months to days, allowing teams to focus on system innovation rather than low-level tuning.

For robotics developers, this means faster iteration, easier performance tradeoff analysis, and a scalable path from prototype to production. As AI becomes the core of autonomy, such integrated toolchains will define how quickly ideas move from the lab to the factory floor or the field.
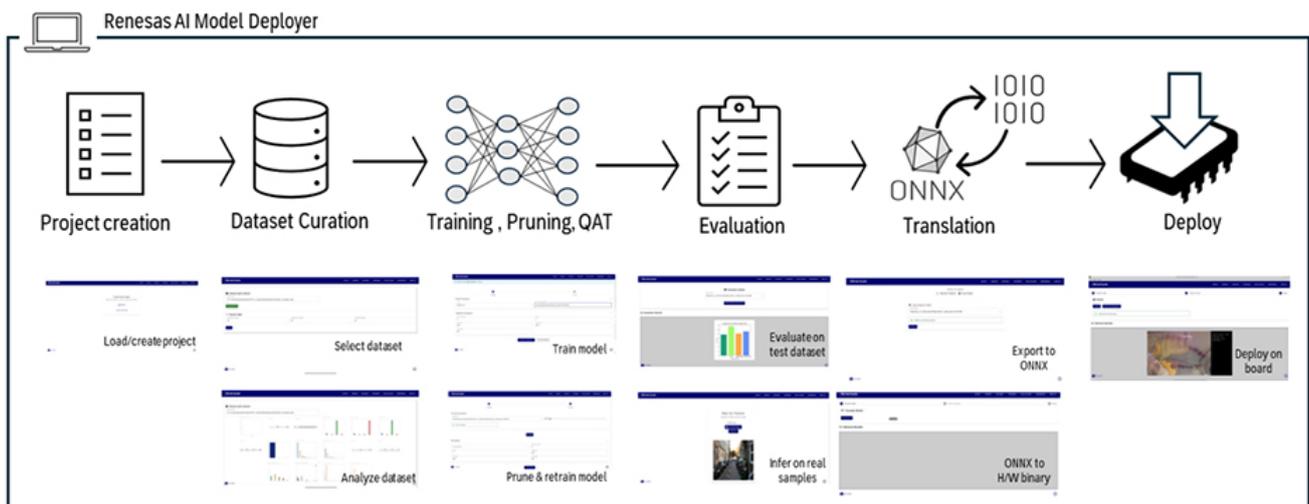
Conclusion

The future of robotics will be defined by convergence where edge AI, deterministic control, seamless connectivity, efficient power delivery, and certified safety come together as a unified system. This integration unlocks robots that are not only intelligent but also safe, energy-conscious, and adaptable to dynamic environments.

Achieving this vision requires more than individual components; it demands platforms and toolchains that simplify complexity and accelerate innovation. Solutions that bridge compute, sensing, actuation, and safety will shape the next generation of industrial, collaborative, and service robots.

For developers seeking to explore these possibilities, resources and reference designs are available to help turn concepts into reality. To learn more about Renesas' robotics solutions, please check out our Robotics page.

References

- Precedence Research: Advanced Robotics Market Size, Share and Trends 2025 to 2034

  Advanced Robotics Market Size to Surpass USD 280.01 Billion by 2034

- Robotics Tomorrow: Autonomous Mobile Robots Market Analysis

  [Autonomous Mobile Robots Market Analysis: $3.49B Valuation by 2023, 15.3% CAGR Predicted to 2030 | RoboticsTomorrow](#)

- Grand View Research: Service Robotics Market (2024 - 2030)

  [Service Robotics Market Size, Share & Growth Report, 2030](#)

- Research and Markets: Humanoid Robots Market Global Outlook Report 2025

  [Humanoid Robots Market Global Outlook Report 2025: Key](#)

Related Information

- [DRP-AI](#): AI Accelerator

- [RZ/V2H:](#) Quad-core Vision AI MPU with DRP-AI3 Accelerator and High-Performance Real-time Processor

- [RZ/V2L:](#) General-Purpose Microprocessor Equipped with Renesas' Original AI Accelerator "DRP-AI", 1.2GHz Dual-Core Arm Cortex-A55 CPU, 3D Graphics, and Video Codec Engine

- [RZ/V2N](#): 15TOPS Quad-Core Vision AI MPU with 2-Camera Connection and Excellent Power Efficiency

- [RA4T1](#): RA4 Series 100MHz Arm Cortex-M33 Motor Control Microcontroller

- [RX24T](#): 32-Bit Microcontroller with On-Chip FPU Enable to Drive Two Motors Simultaneously

- [RX72M](#): High-Performance 32-bit Microcontroller for Industrial Network Solutions

- [RZ/T2H](#): Advanced High-End MPU with Integrated Powerful Application Processing and High-Precision Real-Time Control for 9-Axis Motor Control

- [RAA3064002GFP](#): Resolver-to-Digital Converters

- [SLG47115](#): HVPAK Programmable Mixed-Signal IC, VDD Range: 2.3-5.5V, 10 GPIOs, 2 ACMPs, I2C, Dual Half-Bridge Driver (26.4V, 3A)

- [ISL28022](#): Precision Digital Power Monitor

- [IPS2550](#): Inductive Position Sensor for High-Speed Motor Commutation

- [CN317-ABSIPSPOCZ](#): Absolute Inductive Position Sensor Reference Design

- [ISL3172E](#): ±15kV ESD Protected, 3.3V, Full Fail-Safe, Low Power, High Speed or Slew Rate Limited, RS-485/RS-422 Transceivers

- [DA14531MOD](#): SmartBond TINY Bluetooth Low Energy Module

- [DA16600MOD](#): Ultra-Low Power Wi-Fi + Bluetooth Low Energy Combo Modules for Battery Powered IoT Devices

- [PTX105R](#): Mid-power, Multi-protocol NFC Forum Compliant Reader

- [ATLAS (Asset Tracking & Locationing at Scale)](#)

- [RAA215300](#): High-Performance 9-Channel PMIC Supporting DDR Memory, with Built-In Charger and RTC

- [DA9141](#): High-Efficiency, High Current, Quad-Phase, Step-Down DC/DC Converter (Buck) PMIC

- [IEC 61508 Functional Safety for Industrial Applications](#)

- [AI Model Deployer](#): Renesas AI Model Deployer for Vision AI Solution Toolkit

- [NVIDIA's TAO](#)

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