Whitepaper

Enabling Physical AI and Robotics: The Synaptics Platform for the Intelligent Edge

March 2026

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Physical AI has emerged as an essential technology driving the future of robotics — it closes the loop between perception, reasoning, and action in the real world using powerfully trained AI models. But for robots and autonomous machines, that loop only works well if it runs where the world is actually sensed: at the Edge. Instead of streaming raw sensor data to a data center for interpretation and waiting for a response, Edge AI pushes the key inference and control decisions onto the robot itself. Physical AI, when driven by Edge AI, is characterized by:

- Real-time control: Enables deterministic, low-latency control powered by modern, resilient AI models.
- Reliability: Local decisions that do not depend on a connection to a remote data center.
- Scale: Physical AI sensors produce enormous amounts of data. Deploying Edge AI silicon can help analyze and distill sensor data down to important features and avoid the costs of large cloud deployments.
- Privacy: Data and operations remain local, including voice and control interfaces.
- Multi-Modal: AI models that can blend vision, touch, audio, and other sensors that understand the relationships among all inputs (much like a human brain).

A wide variety of physical AI robotic form factors will emerge across industrial, commercial, and consumer applications as shown in Figure 1.

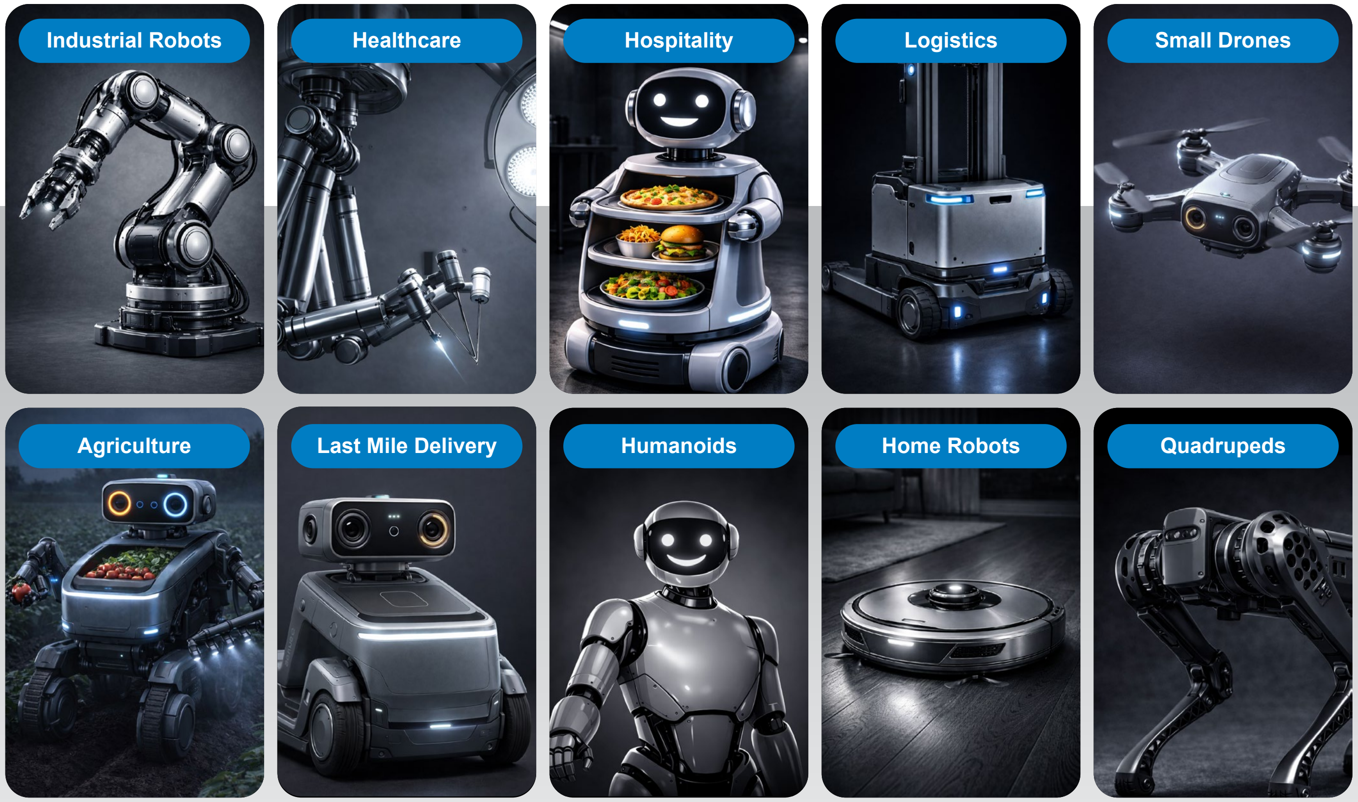

Figure 1. Robot Form Factors: Designed for Every Task

Morgan Stanley Research projects that cumulative robot unit sales will surpass one billion by 2050, signaling a historic inflection point as artificial intelligence moves from the digital realm into the physical world (Source: Morgan Stanley Robotics Almanac: Volume 1 – AI Gets Physical and the Cambrian Explosion of Bots, December 2025). This rapid expansion underscores the emergence of “physical AI,” where intelligence is no longer confined to software, but embodied in machines that sense, decide, and act in real time.

Synaptics is uniquely positioned at the center of this transformation. With decades of leadership and commercial success in human–machine interfaces, Synaptics has built a foundation of products and technologies that naturally extend into physical AI robotics. Synaptics is already operating at high-volume scale across Edge compute, sensing, and connectivity technologies deployed in billions of devices. That manufacturing maturity—qualified silicon, proven supply chain, and production test infrastructure—can be leveraged immediately to accelerate reliable, cost-effective robotics platforms.

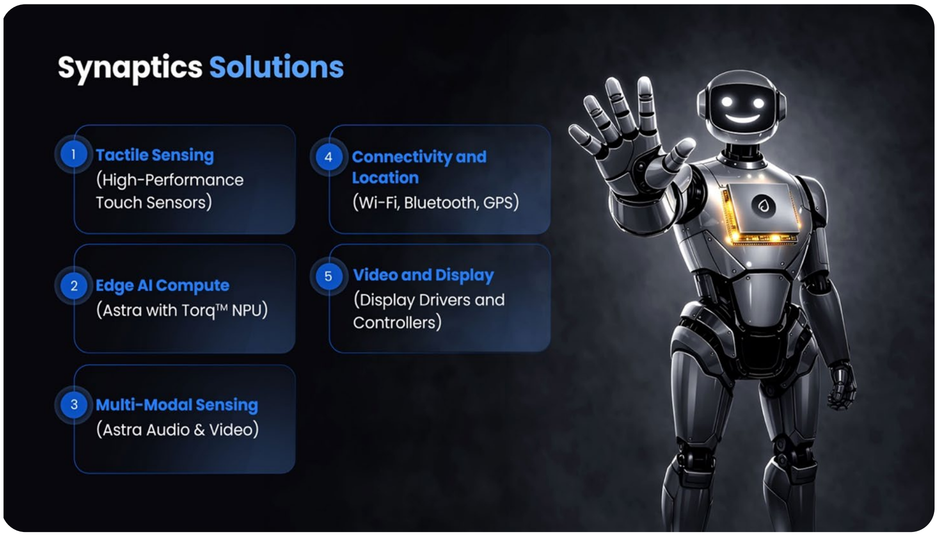

Figure 2. Synaptics Solutions for Physical AI Robotics

As illustrated in Figure 2, Synaptics' core assets map directly into multiple subsystems distributed throughout any robotics platform. Synaptics' key value proposition is to replace simple electronics with intelligent subsystems that handle a hierarchy of sensors and tasks. These capabilities enable robots to interact with their environments—and with people—in more intuitive, responsive, and human-like ways. Synaptics' value in robotics is built on five pillars:

- Tactile Sensing: High-performance touch sensors provide fine-grain tactile sensing for robotic hands. Subsystem examples: robotic hand, gripper, and foot contact sensing.
- Edge AI Compute: Astra™ processors drive Edge AI processing with the Torq NPU for native, local AI models. Subsystem examples: main controller, manipulation controller, perception hub.
- Multi-Modal Sensing: Astra audio, vision, and sensing devices capture and condition physical AI data for robust perception in real-world environments. Subsystem examples: robotic hands, head or perception module, voice interface, presence detection.
- Connectivity and Location: World-class Wi-Fi®, Bluetooth®, and GPS wireless controllers provide reliable data links, fast roaming, and precise local awareness for fleets operating at scale. Subsystem examples: fleet connectivity, monitoring, indoor/outdoor navigation.
- Video and Display: Rich human-machine interfaces include on-robot displays and efficient visual links for remote operation and training. Subsystem examples: on-robot display, remote headset for training.

Synaptics solutions leverage distributed machine learning at the intelligent Edge to seamlessly orchestrate the full robotics system. From touch and other sensor inputs to distributed motor control, audio and video processing, and secure device connectivity, Synaptics technology unifies these elements into a cohesive, intelligent platform—enabling robots that are not only autonomous but perceptive, adaptive, and deeply integrated into the real world.

Pillar 1: Tactile Sensing

The human body has exceptional dexterity, enabled by millions of touch points that help it understand the physical world. The next phase in robotics is to give physical AI models the same level of physical sensation. Fine-grain touch sensors can enable robotics to understand the surfaces and forces in the real world and provide critical safety feedback as they interact with their environment, including other machines and people moving around them. Today, robots have multiple touch sensors embedded in the fingers, manipulators, and feet. Over time, this is expected to scale to many more touch points.

Synaptics leads the industry with AI-ready touch sensing technologies, including high-volume touch technology used in mobile phone touchscreens and personal computer touchpads. These products analyze hundreds of touch points on a screen or laptop and use AI to discriminate between touch and water drops on the screen, or to reject an accidental palm touch. With this market and technology leadership, Synaptics is best positioned to provide the same level of sensor coverage across robotic surfaces.

Tactile feedback can be measured using several approaches, including capacitive, resistive, magnetic, and strain-gauge technologies. Robots often combine multiple methods to maintain accuracy and reliability across varying operating conditions. Synaptics focuses on capacitive touch sensing, delivering high performance in a compact form factor that scales efficiently for high-volume manufacturing.

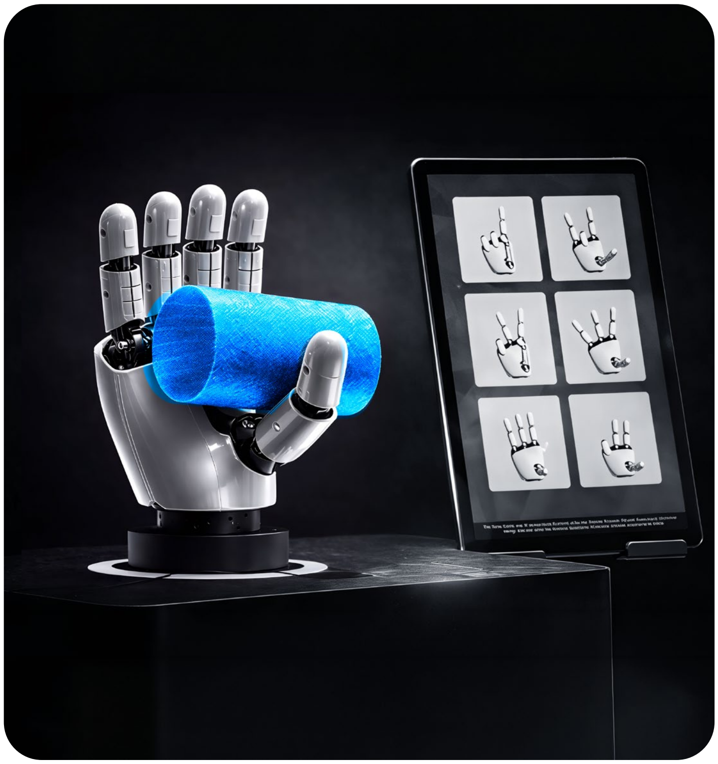

Figure 3. Synaptics Tactile Sensing for Robotic Hands

The most important feature of capacitive touch is its ability to sense changes in the deformation of a material cavity. For example, as shown in Figure 3, the entire hand can be covered with soft, compressible silicone rubber that holds the capacitive sensors in place for measurement and protects the underlying electronics.

Synaptics capacitive sensors, such as the SN6012T, deliver industry-leading performance for touch controls. Each device, less than 25 mm^2 in size, can sense up to 60 individual touch points at almost 500 times per second. They can share a common I3C interface to connect multiple chips over a 2-wire interface. In this way, touch controller devices can be placed at many points of contact, while simplifying the wiring to the host MCU. The Synaptics SN6012T is known for its industry-leading high signal-to-noise ratio, delivering robust precision and dexterity.

The touch controllers and software can be paired with the Astra line of MCUs to aggregate hundreds of touch points and solve the AI equations to convert the measurements into a touch-force surface map. With this distributed Edge AI compute architecture, the high-bandwidth local touch data is converted into the most useful information for the main control system. All raw data may still be sent to the main NPU, but local AI aggregates the data, sending the overall map and higher priority information first. In addition, event flags may be added. For example, local AI can detect that an object is slipping and send a “Slip Detected!” event flag along with the data, which helps the main NPU to prioritize this data.

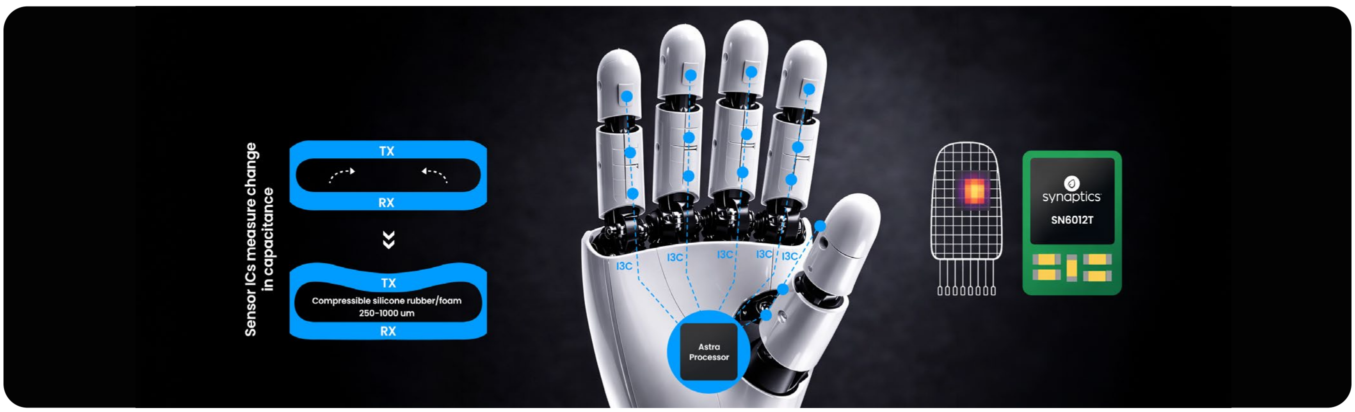

Figure 4. Synaptics Capacitive Touch Sensors

Pillar 2: Edge AI Compute - Astra Processor with Torq NPU

Every robotics platform needs to make millions of decisions per second to process incoming sensor data, move through the world, and translate commands into action. In traditional platforms, the MCU is the workhorse that interfaces with sensors to read data and generates the detailed signaling needed to control actuators, while the data is transported to a high-capacity centralized compute platform. As robots assimilate more functionality, the centralized architecture overloads the main compute platform, resulting in inefficiencies. Therefore, robots are evolving from monolithic compute to distributed architectures with intelligent subsystems. Synaptics’ Astra processors redefine the role of the embedded MCU by replacing it with a powerful Edge AI processor. Instead of just a microcontroller with interfaces, Astra provides an embedded AI platform to handle these tasks with enhanced, distributed intelligence.

AI has upended the way that control algorithms are designed and how perception is handled. Instead of building complicated decision trees for every step, AI frameworks like PyTorch and TensorFlow enable engineers to train models using exemplary data and demonstrations, execute complex tasks through teleoperation mirroring, and use reinforcement learning in a virtual environment. AI algorithms enable robots to learn new policies from data, deploy new tasks more quickly, and operate more robustly across real-world variation.

The nature of AI models is changing as well. The famous 2017 paper from Google, “Transformers Are All You Need,” paved the way for new AI architectures based on transformers, which in turn led directly to the explosion of cloud-based large language models (LLMs). These models provide attention layers that enable the models to extract context and analyze relationships across large datasets. These concepts have now propagated into the Edge models needed for robotics, and researchers are finding new model architectures. The concept of a vision-language-action (VLA) model enables camera-based analysis of a scene, clear language-based instructions for the next steps, and the model directly controlling the actuators to achieve that outcome. Action Chunking Transformers (ACT) are AI models that use imitation learning policies that predict a whole short trajectory of future actions all at once.

Astra Processors

All of these developments formed Synaptics’ definition of its Astra line of processors. Not a single product, but a whole family of processors with a common software framework (and therefore an easy upgrade path), making AI models and compute available to all our customers. Every Synaptics processor combines four main elements:

- Torq Neural Processing Unit (NPU) – ready to implement transformer AI models for robotics
- Host CPU to enable standard software frameworks, like real-time operating systems (RTOS), or even embedded Linux systems like Yocto
- Robust peripherals and sensor connections – from vision MIPI-CSI, display MIPI-DSI, audio PDM microphone support, I3C, UART, SDIO, and SPI interfaces to touch controllers, IMU, wireless, and GPS navigation subsystems
- High-capacity interfaces for host connection – including Gigabit Ethernet, industrial CAN-FD, I3C, and RS-485 for serial connections

The [Synaptics Astra Edge AI processor] is a perfect example of a processor ready to integrate into robotics platforms. It combines the 1 tera-operation per second (TOPs) Torq NPU engine which, through a partnership with Google Research, integrates the open-source Coral NPU. The open-source Torq compiler toolchain takes ready-to-target AI models and executes on-device, while providing future-proof AI architect support with Coral NPU.

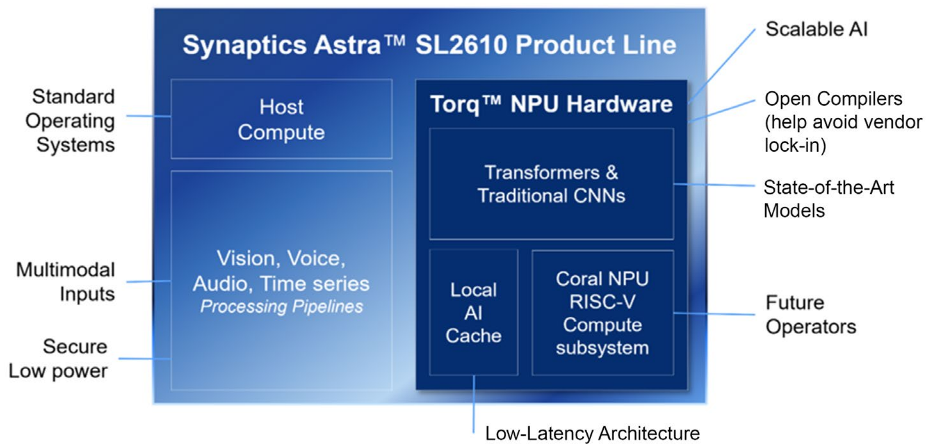

Figure 5. Synaptics Astra SL2610 Family of Edge AI Processors

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With native int8, int16, and bfloat16 data types, Torq is ready to handle computer vision, audio, sensor networks, and with transformer support, it can handle VLA and ACT style models for robotics. On the processor side, it runs embedded Linux on a dual-core Arm Cortex-A55 processor with an on-board GPU for display rendering, and it includes the Cortex-M52 low-power embedded subsystem for background MCU tasks. Including all the peripherals, it supports 12 smart pulse width modulation (PWM) channels, with options for quadrature decoding, stepper motor control, and three-phase motor control.

Distributed Compute

Traditional robot architectures feature a powerful centralized compute with all the data and peripherals routed to it. However, this limits the ability to scale the platform. A better robot architecture is to distribute the compute, enabling subsystems to become encapsulated components with local autonomy to accomplish larger tasks with a subset of instructions. Like software APIs, or microservices in the cloud business, distributed compute offers numerous advantages to robotics platforms:

- Separate development teams focus on their subsystems and solve the real-time latency problems without the complications of resource sharing across a platform.
- Real-time safety systems can work autonomously and guarantee operation even if the main compute platform is not functioning normally.
- Moving to AI models like VLAs, the entire subsystem commands can be simplified into higher-level, text-based commands with full autonomy to accomplish the fine-grained control and objective.
- Mix and match subsystems, where each robotics manufacturer is not starting from scratch to build platforms.
- The main compute can focus on the hardest tasks and overall control, while the distributed compute resources deal with the deluge of high-bandwidth sensor data, and provide only the most significant information or abstracted results.

Precision Dexterity Control

The humanoid robot hand is a concrete example of how distributed control improves the capability of the entire system. As seen in Figure 6, the hand combines the touch sensors, local cameras, and actuators on the fingers. The combination of Synaptics touch ICs – to collect data from hundreds of force-sensing touch points - and the Astra SL2610 processor - to solve equations to convert the touch data into an overall force map - unburdens the main compute platform. The central compute receives the force map, but it is not directly involved in managing sensors or low-level sequencing. Even more powerfully, the Torq NPU can run AI models to blend touch and vision data to control the hand itself. In this case the main platform sends a high-level command, like “grip this object with 20 Newtons of force” or “apply 10% more force if slippage is detected”, and the trained AI models do the rest, performing object detection with cameras, closing the various fingers, all while monitoring the force equations. Safety plays a critical role and additional policies, such as limiting the maximum force, can prevent actuators from performing movements that might be unsafe.

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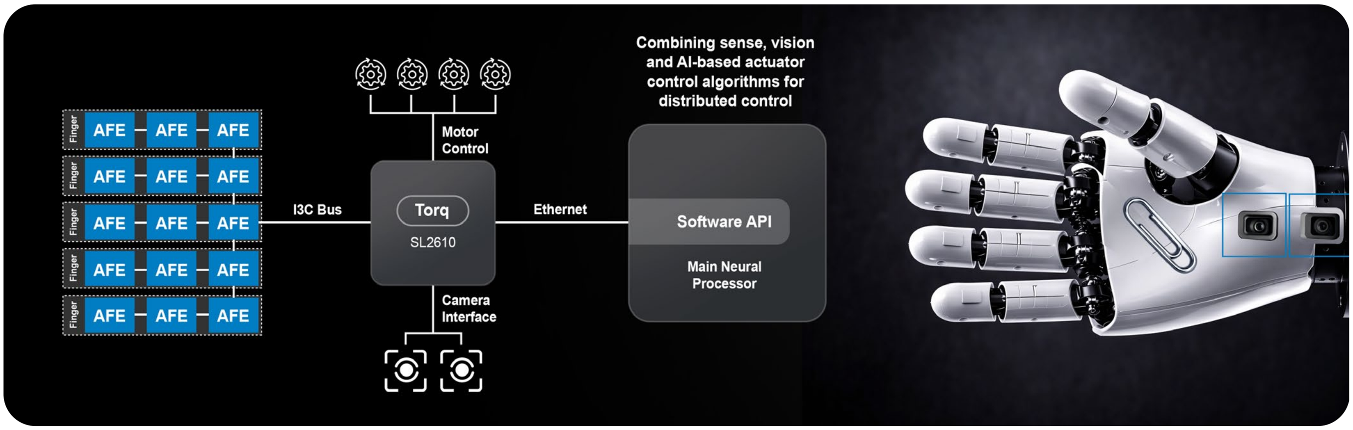

Figure 6. Hand Aggregator Unit, Astra Distributed Compute

Safety Critical Systems

Another benefit of distributed compute is to provide an independent safety-critical oversight on the operation of the entire robotic system. Compute platforms are not perfect, and during a complex task real-time software can be overloaded and not provide timely analysis on all safety checks. Using a distributed compute strategy on a factory floor or home services robot, like an Astra processor with Torq NPU, can provide an independent system that is continually running AI models to look for safety conditions, like a person moving past, and take immediate action.

Figure 7. Independent Safety Awareness

Pillar 3: Multi-Modal Sensing – Far-Field Audio & Computer Vision

Audio Noise Suppression, Beamforming

Robots operate near humans, and natural language voice interaction is the most immediate and intuitive human-machine interface. Synaptics is a leader in AI audio technology, already shipping ICs in millions of headphones. These provide a robust interface using AI-based noise suppression, voice ID, and multi-microphone beamforming. The multifunction SR80 silicon provides multi-microphone processing and the ability to drive multiple speakers when combined with CX9000 devices.

One application of multi-microphone processing that has been deployed in commercial kiosks is the ability to determine the angle of arrival of a person's speech. In a robotics platform, this provides situational awareness on where voice commands originate. A factory floor or a crowded public area may be noisy, and neural noise suppression enables voice interactions with clear understanding.

Figure 8. Environmental Noise Cancellation, Multimodal Voice Recognition with Depth Map and Person Recognition

Computer Vision

Synaptics audio solutions can be further enhanced by combining them with our computer vision processors to provide face identification and user tracking. This further situational awareness can identify the speaker, thereby allowing the robot to personalize and prioritize the user's commands. By correlating the user in frame with the angle of arrival, the microphones can be pointed to amplify the identified user and reject distractions, such as other speakers in the vicinity.

As shown in Figure 9, the combination of SR80 for audio, SR110 for computer vision, and CX9000 for driving speakers provides the elements needed for a reliable voice interface.

- Up to 8 microphone support with high performance DSP and onboard NPU compute
- Stereo smart amplifier with 2x15 W output power
- Multi-user presence/attention detection with biometric face ID
- Voice tracking AI noise reduction
- AI sound event detection and key-word spotting capability
- 4 channel acoustic echo cancellation
- Microsoft Teams v5 certification and Zoom certification for audio performance

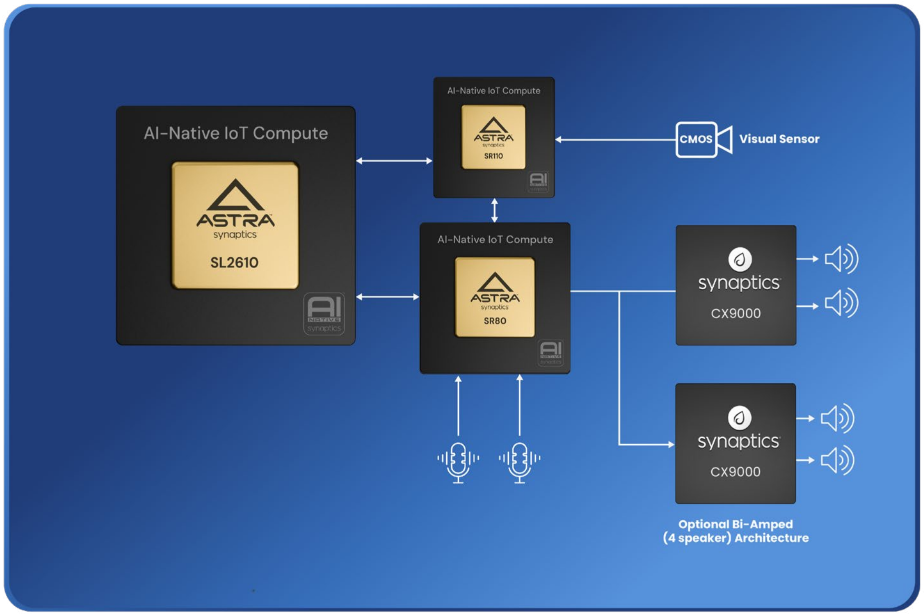

Figure 9. Synaptics Voice & Vision Reference Design

AI Voice Assistant

Robots must understand conversational language to interact with humans around them. Synaptics Astra processors provide the platform to enable an AI voice assistant that bridges the user's intent into action and robot responses. The key components of a voice assistant are:

- Voice Activity Detection (VAD) – detecting when a user is speaking while rejecting background noise
- Speech-to-Text (STT) – converting sound energy into live-transcript text tokens
- Small Language Models (SLMs) – processing of commands and analysis of response
- Text-to-Speech (TTS) – synthesizing a voice response on the fly, allowing closed loop interaction

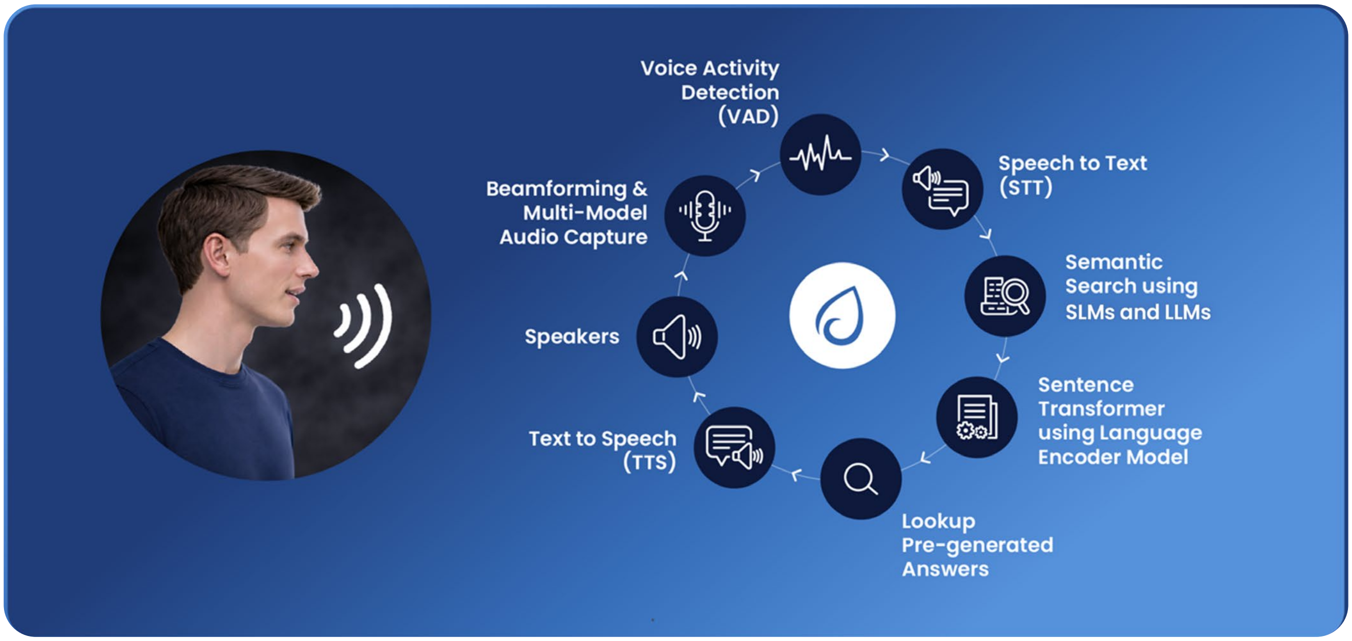

Figure 10. AI Voice Assistant

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As such, the full voice solution requires close interaction among multiple AI models. Speech-to-Text and Text-to-Speech are foundational AI models whose performance has been unlocked with the power of transformer-based neural architectures. The Torq core is an ideal Edge compute platform for implementing these models. At the most basic level, SLMs are sentence transformers that compare a user's question against an internal dataset and respond with the closest semantic match. Sentence transformers are derived from large language models (LLMs) and use language structure to map different ways of asking a question or expressing a statement into a similarity score to interpret them.

The Synaptics Astra team has partnered with Google Research to provide an even higher level of Edge intelligence. As a result of this partnership, newer LLMs like Gemma 3 270m can run locally on Torq to provide a powerful language agent that can be fine-tuned and trained to understand and react to complex interactions. With this LLM capability, robots understand imperative commands and queries such as, “Come to me”, “What other actions can you help me with?”, and so on. With the voice assistant running as a subsystem of a distributed processor, it can react quickly to emergency verbal safety commands like “Stop!”, “Halt!”, or “Don't do that!”, while simultaneously providing natural language mapping to the same outcome.

Pillar 4: Connectivity and Location – Wi-Fi, Bluetooth, and GPS

Connectivity You Can Count On

Reliable wireless connectivity is critical for robotics platforms as they move through the real world. Most operating environments include Wi-Fi coverage, and taking advantage of the Wi-Fi 7 standard enables data rates up to 6 Gbps for high-bandwidth, low-latency connections. Whether in the home or on the factory floor, high-bandwidth data connections enable streaming data for real-time supervision, remote teleoperation, and large-scale data collection for AI training. In large deployments, the coordination of a fleet of robots requires low-latency connectivity and precise location information to be fed into supervisory control systems.

Figure 11. A Team of Robots and Its Environment: The Importance of Robust Connectivity

Synaptics' SYN4390 and SYN4384 connectivity devices feature the latest Wi-Fi 7 functionality. The step up to Wi-Fi 7 over Wi-Fi 6 brings a series of improvements critical to robotics infrastructures:

- Doubling bandwidth to 320 MHz channels
- 20% higher throughput with advanced 4096-QAM modulation
- Multi-link operation (MLO) with intelligent connections across 2.4, 5, and 6 GHz bands
- 6 GHz operation, opening new spectrum and avoiding congestion in the 2.4 and 5 GHz bands
- Lower latency
- Doubles the capacity of Wi-Fi 6 with multi-device connections in high-demand environments
- Fully backward compatible with Wi-Fi 6 infrastructure

Synaptics Wi-Fi connectivity devices are multi-function ICs that also integrate Bluetooth and BLE functionality, IEEE 802.15.4 support, and a dedicated Wi-Fi coexistence engine. Bluetooth classic links provide the human interface and teleoperation on gamepads, joysticks, and custom HID profiles, as well as hands-free profiles for audio and voice connections. Bluetooth Low Energy (BLE) adds low-power sensor peripheral links, proximity and positioning features, advertising beacons for identification, state or presence, and Bluetooth mesh support for many-node networks. Synaptics supports the latest Bluetooth Core 6.0, which adds distance estimation between two connected BLE devices using phase-based ranging and round-trip time estimation.

In addition, the IEEE 802.15.4 radio adds Thread and Zigbee protocols, allowing the platform to engage with smart home devices (lights, doors, and sensors).

Wi-Fi 7 with Fast Roaming

SYN4390 is optimally designed for the robotics space as it features a Real Simultaneous Dual-Band (RSDB) along with a dedicated scanning receiver. This means the device can support simultaneous traffic on two different bands (such as 2.4 GHz and 5 GHz) while continuously scanning for the next available access point in parallel. Packet transfers occur in parallel providing increased throughput and reduced latency compared with transferring packets serially.

In situations such as a fleet of robots moving through a factory, the scan core is a high-performance option ensuring robust, uninterrupted connectivity as robots move between access points. With the scan core, the robot can continually scan for the next available handoff point to avoid dead zones in connectivity. As a result, the speed of the robot can be increased across these handoff zones.

SYN4390 has three modes of operation: Simultaneous Dual Band (SDB), Turbo, and Low Power. In SDB mode, multiple wireless traffic channels are active, while in Turbo mode the device maintains SDB traffic and activates the scanning channel in parallel. Low Power mode only enables the scanning channel while the main radios are disabled to reduce power.

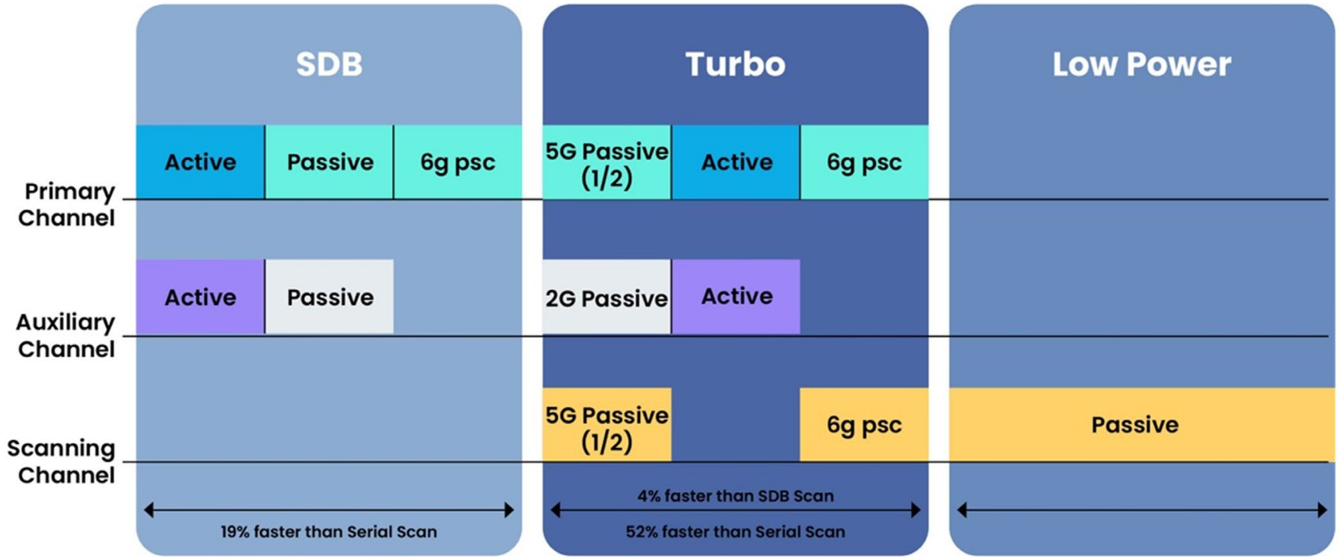

Figure 12. Advantages of Simultaneous Dual-Band (SDB) and Scan Core

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Global Navigation Satellite Services (GNSS)

Accurate location information is a critical element in coordinating fleet operations and enabling autonomous completion of complex tasks. Synaptics has a portfolio of GNSS devices in high volume production, such as popular biometric-tracking smartwatches, that provide high-accuracy location information to robotics platforms. For example, consider a dark factory where computer vision AI may not work; GNSS location information keeps devices on track.

The SYN4778 provides best-in-class standalone GNSS, supporting both legacy L1 and modernized L5 signals. L5 is a modernized GNSS signal launched in newer satellites designed for higher accuracy and robustness, especially in challenging RF and urban environments. By using 10x wider bandwidth, higher transmit power, and transmitting in a new band, L5 GNSS signals enable a sharper correlation peak, and new spreading codes make it more difficult to jam the signal.

These devices can be combined with an Astra MCU to apply Real-Time Kinematic (RTK) and thereby achieve further accuracy out of GNSS. The typical RTK signals use an adjacent base station with a known location, and can cancel shared errors like satellite clock errors, ionospheric, and tropospheric delays.

Pillar 5: Video and Display

Remote Control System – Vision and Haptics

Figure 13 illustrates a human training a robot to perform a task. This setup typically includes a headset that mirrors the robot's visual perspective, along with hand controls that provide haptic feedback. Many of these systems, such as quality control stations and surgical instruments, require extreme precision and accuracy in both vision and manual control.

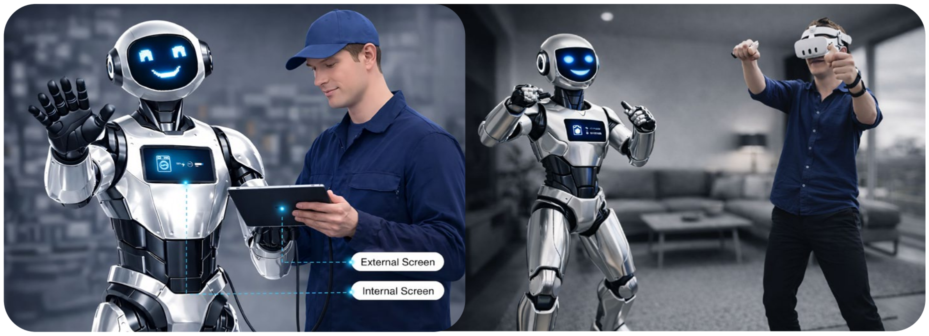

Figure 13. Internal and External Displays in Robotic

Synaptics AR/MR/VR display drivers support high-resolution 2K/3K per eye displays for both LCD (R63455) and OLED (R66471), bringing users a more immersive experience than ever before. In addition, Synaptics offers complementary display bridges, VXR7200 and VXR8300, to drive high-resolution binocular AR/VR headsets.

Synaptics capacitive touch and force-sensing technologies integrate haptics for intuitive and responsive controls. With AI built in, these solutions support accidental contact mitigation.

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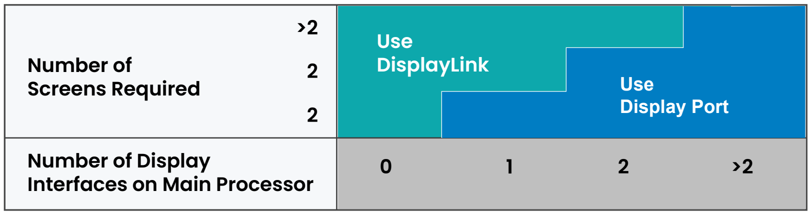
Video Connectivity – DisplayPort and DisplayLink™

Robots often include internal displays to present video or graphics to nearby users. They may also support external display connectivity for diagnostics, maintenance, training, or other purposes.

Most video or graphics interfaces are designed for either internal screen connectivity (MIPI, LVDS) or external screen connectivity (HDMI), but not both. This is because the electrical characteristics are not compatible between internal and external connectivity. However, DisplayPort (over eDP, DP, or USB-C) and DisplayLink (over USB, Ethernet, or PCIe) are unique in that they are architected for both internal and external device-to-device connectivity.

Interface	Internal Screen	External Screen
DisplayPort	Yes>8”	DP, USB-C
DisplayLink	USB, PCIe	USB, Ethernet
HDMI	No	Yes
MIPI	Yes<8”	No
LVDS	Yes<8”	No

DisplayLink is a proprietary interface owned by Synaptics that uses a software driver to encode video and graphics for transmission over data connections such as USB, PCIe, Ethernet, or Wi-Fi. Because the display path is abstracted into software and data, DisplayLink is not tied to a particular graphics API, vendor GPU, or port architecture. As a result, DisplayLink has remained compatible across CPU transitions (x86 to ARM), OS changes (Windows, macOS, Android, iOS, Linux, etc.), and new connectors (USB, USB-C, PCIe, Ethernet, etc.).



The question of whether to use DisplayPort or DisplayLink depends on display requirements relative to the number of native display outputs in the main computing processor (CPU). Some processors have no native graphics outputs. In this case, DisplayLink can be used when a graphics display is required. On the other hand, even if the CPU has one or more display outputs (DisplayPort or others), DisplayLink is a good option if additional displays are required. Otherwise, DisplayPort may be used.

Synaptics Powers the Next Generation of Intelligent Robotics

Robots are rapidly evolving from purpose-built machines into adaptive, multi-sensor, always-connected systems that operate safely alongside people. This shift to “Physical AI” demands far more than raw compute. It requires a coordinated set of capabilities at the Edge: rich sensing, low-latency decision making, robust wireless connectivity, intuitive human interfaces, and efficient pathways to visualize, manage, and update systems in the field.

Synaptics is uniquely positioned to enable this transition, as our portfolio spans the full set of building blocks needed to create intelligent, scalable robotic platforms. As described in this paper, we bring together five foundational pillars:

- Tactile and touch sensing to give robots fine-grained environmental awareness and dexterity for safe, precise interaction.
- Edge AI processing to run perception and control workloads locally with predictable latency, power efficiency, and reduced dependence on cloud infrastructure.
- Audio and vision technologies that enable natural interaction (voice and presence), spatial awareness, and advanced perception.
- High-performance wireless connectivity designed for dense, real-world deployments where reliability, roaming performance, and responsiveness matter.
- Human interface and display solutions that support visualization, control, and collaboration—whether embedded directly in a robot or delivered through external displays and peripherals.

Together, these capabilities support a modern robotics architecture where intelligence is distributed across specialized subsystems. Instead of forcing every function through a single centralized processor, robotic designers can deploy purpose-built modules—each optimized for sensing, actuation, interaction, or connectivity—improving scalability, reducing integration complexity, and accelerating time to market.

This portfolio breadth represents a compelling expansion of Synaptics' role in the intelligent Edge: multiple high-value attach points per robotic platform, opportunities to increase content per device, and durable differentiation through integrated hardware and software solutions. For customers, it translates into practical advantages: faster development, lower system risk, and a clear path from prototype to production through proven components and reference architectures.

If you are building the next-generation of intelligent machines—humanoids, mobile robots, industrial automation, or service platforms—Synaptics is ready to engage. Contact our team to explore reference designs, evaluation platforms, and subsystem solutions that can accelerate your roadmap and help bring reliable, production-ready physical AI to market.

https://www.synaptics.com/contact/synaptics-sales