

How edge AI-accelerated Arm® Cortex®-M0+ MCUs bring more brain power to electronics



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Key takeaways

- **TI microcontrollers (MCUs) with integrated neural processing units (NPU)** provide hardware acceleration for edge AI, helping designers deploy sophisticated neural network models for real-time, localized sensor data processing in power-constrained, cost-sensitive applications.
- Running machine learning inference on MCUs enables advanced capabilities including **wake-word detection, gesture recognition and predictive maintenance**.

Making edge AI more accessible with MCUs

Today's general-purpose MCUs, especially those with integrated AI hardware accelerators such as TI's TinyEngine™ NPU, make it possible to run sophisticated models in products that need to balance power consumption, size and cost constraints while increasing system responsiveness.

These feature-rich devices allow engineers to implement AI features without relying on continuous cloud connectivity to remote servers, enabling smarter, faster and more reliable user experiences across a range of applications.

In this article, I'll explore several examples highlighting how to deploy AI models on Arm® Cortex®-M0+ based MCUs such as the [MSPM0G5187](#). Each example covers the sensing and signal-processing chain, how the AI model fits into the embedded environment, and the performance and system-level advantages that MCUs bring to each design.

Wake-word detection in smart home devices

In smart speakers ([Figure 1](#)) and hubs, AI models power the voice-recognition ability to wake upon user request.



Figure 1. Smart speaker with voice-recognition features

The user's voice creates sound waves processed as measurable acoustic pressure, which the AI model needs to capture and process before responding. Figure 2 is a block diagram showing the format and flow of data in the system.

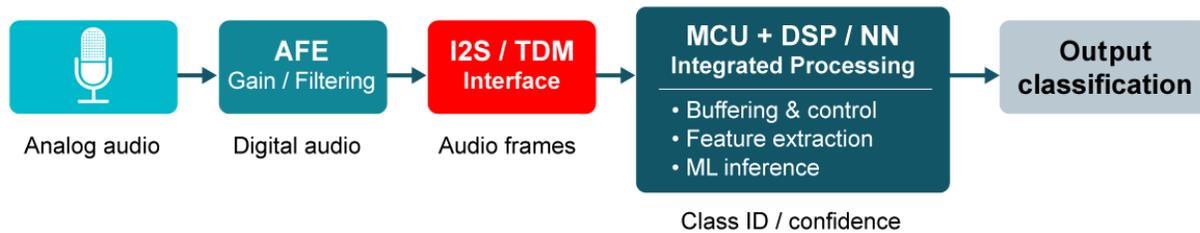


Figure 2. Signal-chain block diagram for a voice-recognition application

In this signal chain, an analog sensor such as a microphone captures raw waveforms, which are then passed onto an analog front-end device to improve the signal amplitude, filter out noise, and encode the data into a digital format. An MCU receives the data through a communication protocol such as I2S for audio and interprets the data through an on-chip neural network model to determine whether specific keywords were spoken. If so, the system recognizes a valid wake-up condition and a more powerful processor in the system comes online, either to perform heavy-duty computations for the requested task, or to delegate the user prompt wirelessly to a cloud-based AI model.

In voice-enabled products, speed and performance accuracy are the priorities; a highly responsive system that gets the user's request right on the first try reduces the need to repeat commands or excessive idling. The device needs to be continuously listening for wake-up commands and process voice data quickly, a functionality that requires low-latency and low-power performance.

MCUs fulfill power requirements in voice-recognition applications by consuming only tens of milliwatts – a hundredfold improvement compared to voice processor integrated circuits (ICs) that consume full watts of power. In terms of latency, an AI keyword recognition model using a 1D convolutional neural network can **reduce processing time by more than 90x** with an NPU when compared to the same model running on an MCU with only a standard CPU.

Gesture and activity monitoring in wearable health trackers

In wearable personal electronics such as smart rings and watches (Figure 3), touch-free gesture recognition is accomplished through sensors tracking hand and body movement. The same sensors can also record health and behavioral data to determine insights on fitness as well as sleep and stress levels.

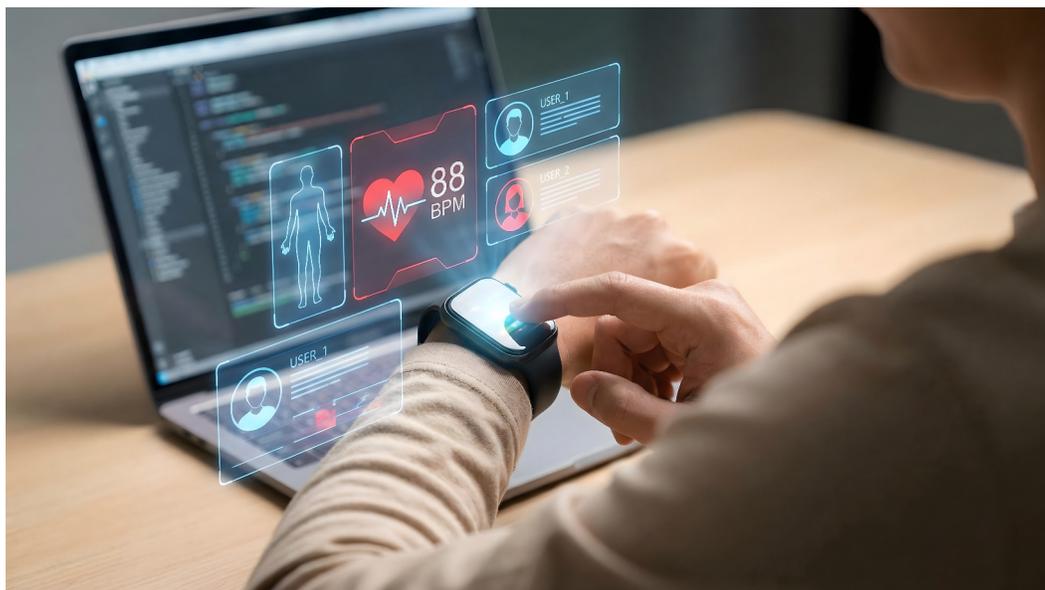


Figure 3. A wearable fitness tracker displaying biometric data

The signal chain block diagram in Figure 4 shows how the AI model measures and analyzes gestures. Analog sensors such as accelerometers and gyroscopes capture human motion and orientation; these sensors then pass signals through the signal chain for preprocessing and measurement. An MCU receives the data and runs the AI model in order to recognize specific gestures like a sudden flick of the wrist. The same concept applies to other types of data such as heart rate, sinus rhythm and sleep patterns; it just requires the appropriate sensor in the system's design.

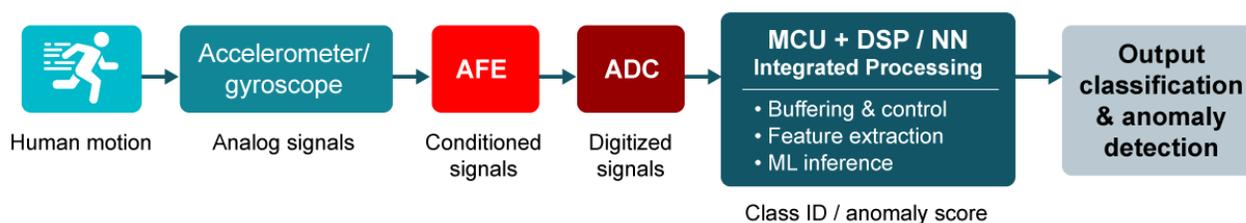


Figure 4. Signal-chain block diagram for a gesture-recognition wearable application

Wearable health tracker designers are seeking to develop solutions that are small and lightweight for everyday wear while having the ability to recognize gestures accurately and quickly. An MCU can address these technical requirements with efficient computing capabilities and high integration of analog and digital peripherals in a tiny IC footprint occupying only a few square millimeters on the printed circuit board (PCB). This design approach enables smaller designs than those with discrete components ever could, which you can see in the trend of modern smart accessories continuing to add features while generally remaining the same size.

Motor vibration detection in industrial motors

Whether it's a conveyor, pump or actuator, mechanically moving parts in industrial motors (Figure 5) may fail over time and lead to unwanted disruptions. Local AI models can monitor motor signals and seek out time-domain anomalies such as small impulse spikes and irregular periodicity that don't immediately halt motor function but do indicate imminent failure.



Figure 5. Industrial motor

Figure 6 shows a signal chain for measuring electrical waveforms and performing data preprocessing tasks for cleaner input into the AI model. The MCU in this application uses AI models for motor fault analysis to detect anomalies early and warn the system or its operator.

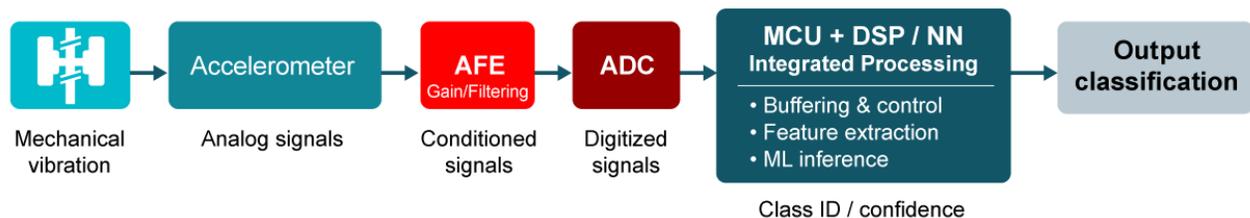


Figure 6. Signal-chain block diagram for mechanical vibration monitoring in an industrial motor

Since humans are often present in these environments, machine failures also need to be predictable and preventable to ensure safety. Edge AI-enabled MCUs provide versatility in these environments by deploying AI models to help monitor important motor signals directly for signs of failure. These models can excel at identifying patterns in data to intervene decisively, serving as a powerful tool in motor systems.

Bringing more intelligence to the edge with MCUs

The most exciting thing about edge AI-accelerated Arm Cortex-based MCUs like the [MSPM0G5187](#) is their versatility in general-purpose applications. There is nearly an endless variety of electronics in which designers can find novel ways to deploy low-power, low-latency AI capabilities. The goal for MCU manufacturers is to continue integrating these advanced capabilities while deploying easy-to-use development resources and scalable platforms.

Additional resources

- Learn more about TI's [edge AI portfolio](#).
- Get started on your design today with TI's free [CCStudio™ Edge AI Studio tools](#).
- Read about the TinyEngine NPU and its benefits for edge AI-accelerated embedded designs in the product overview, [TI's TinyEngine™ NPU unlocks edge AI acceleration in more embedded systems](#)

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