

NanoEdge™ AI Studio from Cartesian: True Endpoint AI, fast and simple

Case Study

Goal

Making endpoint AI ready objects is complex as it requires two separate worlds to come together: Data scientists and embedded developers. Cartesian built a software solution to address this complexity, enabling embedded developers to easily and quickly deliver – in a matter of hours – a full end-to-end endpoint AI solution without any prior skills in AI.

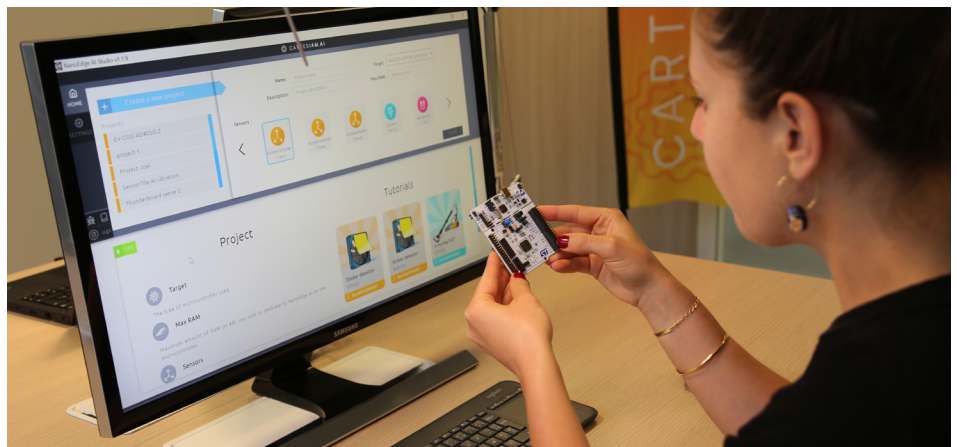
Challenge

Training a model for creating smart devices requires datasets, data scientists, and implies cloud computing cost. Cartesian addressed this complexity by developing a unique technology that allows model creation and training to take place directly in the microcontroller and to be based on signals captured in the devices.

Solution

[NanoEdge AI Studio](#) is a development environment aimed at embedded developers to create a machine learning (ML) library in just a few steps and without any prior knowledge in signal processing or data science. The output is an ML library, extremely optimized in terms of RAM (0.5Kb to 10Kb) and running on any Arm Cortex-M microcontroller.

Figure 1
Cartesian's environment



**NANOEDGE AI
STUDIO** By Cartesian 

Benefits

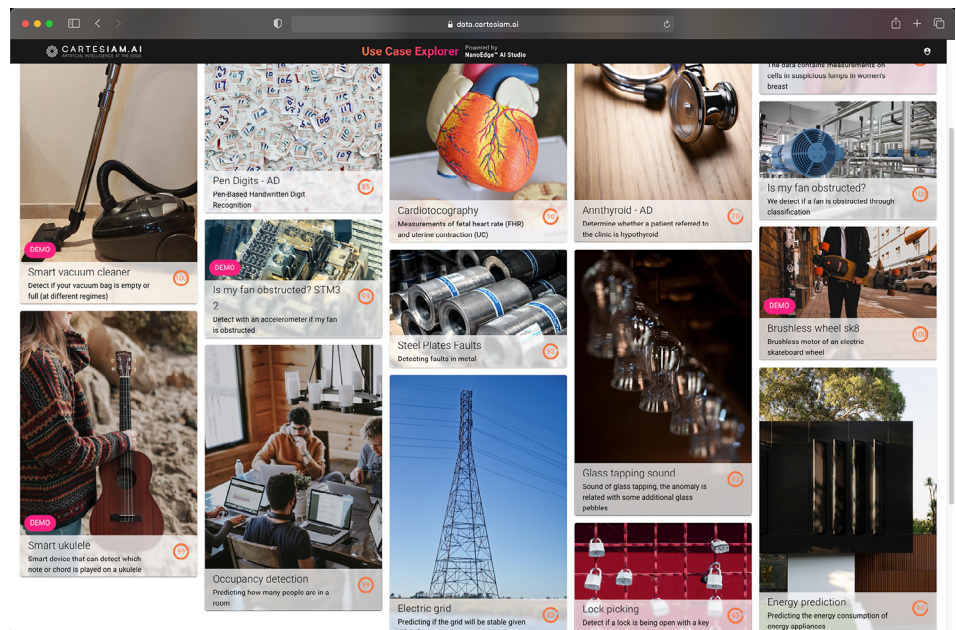
- + Simple and fast way to deploy AI in your product
- + Available to all embedded developers for use in any Arm Cortex-M based product
- + Proven technology already deployed in existing products

Applications

NanoEdge AI libraries can be deployed in any device containing an Arm Cortex-M microcontroller, from the smallest Cortex-M0 to the most powerful Cortex-M7. The solution is industry agnostic and targets applications such as predictive maintenance, fraud detection and security. It enables both anomaly detection and signal classification, using any signal type (vibration, current/voltage, magnetism, etc.) as input.

Figure 2

Use case explorer powered by NanoEdge AI Studio



Use cases embedding predictive maintenance capabilities that benefit consumers and industrials already exist.

Predictive maintenance in industrial environments with Lacroix Electronics

- + Filter clogging prediction in industrial reflow ovens

Predictive maintenance and anomaly detection with Bob assistant

- + Critical failures prediction on rotating machines
- + Anomaly detection on industrial motors or pumps



Figure 3

Bob assistant



Design challenges

Microcontrollers are often designed for resource-constrained applications and therefore have limitations including memory (RAM and Flash) capabilities and processing speed, compared to desktop or server-class processors. These limit the possibilities of embedding cutting edge machine learning solutions on such resource-constrained hardware. Another difficulty is abstracting away the complexity of all ML components, in a tool that can be understood and used, quickly and easily, by embedded developers without any skills in ML.

Design implementation

The ML and signal processing algorithms have been adapted by our R&D team for microcontroller starting from the algebra, bearing in mind the specific limitations of microcontrollers. We devoted more than three years of R&D for that purpose and filled several patents. This has resulted in new methods that are extremely fast and memory efficient. All ML steps can easily be run within the MCU (even model training, which is unique on the market today). We also opted for incremental learning and inference in-situ. Incremental learning allows a constant adaptation of the model to the environment of the device (for example changing environmental conditions). There is no need to store raw data in the microcontroller or transmit data anywhere, which is crucial for efficiency and security.

To solve the compatibility issue; we did two things.

- + For embedding AI libraries, we decided to focus on Arm Cortex-M architectures to be compatible with as many end products using microcontrollers as possible.
- + For testing the library's performances before embedding, we built a dedicated tool, the Emulator, which is packaged into NanoEdge AI Studio, and enables quick testing of any library (among millions) and all their features, without having to worry about compatibility.

To address the ML complexity concern, we developed NanoEdge AI Studio as a tool to automatically build and select the best ML library, taking only a few signal examples as input. These examples of raw signals, for instance vibration or current, can be measured directly on a target equipment that is representative of the final environment to be monitored, but not necessarily exactly this one.

Although the tool provides a way to quickly implement powerful ML capabilities into any code, there is no aspect of ML involved in the workflow at all.

Why Arm

We chose to make all our ML libraries compatible and easily deployable on any Arm Cortex-M architecture for various reasons:

- + The range of available, compatible Arm-based microcontroller platforms is immense.
- + We can take advantage of the Arm ecosystem, both from a community support and tooling point of view.
- + Arm microcontrollers provide the low-power consumption levels that our customers need.

Looking ahead

The new Arm Cortex-M55 processor with integrated processing technology for enhanced ML is a clear demonstration of Arm's leadership in our space and innovation capabilities. We are working closely with Arm to ensure that our solution takes full advantage of the latest developments built at the heart of this new processor to bring the best of artificial intelligence to our customers.

We believe this technology will play a key role in battery management systems, as it will monitor a car battery, detect aging, and prevent battery failures for example.

About Cartesiam

Cartesiam, founded in 2016, is a software publisher specializing in artificial intelligence development tools for microcontrollers. NanoEdge AI™ Studio, Cartesiam's patented development environment, allows embedded developers, without any prior knowledge of AI, to rapidly develop specialized machine learning libraries for microcontrollers. Devices leveraging Cartesiam's technology are already in production at hundreds of sites throughout the world.

Whatever the industry, Cartesiam brings immeasurable benefits to its customers involved in projects integrating microcontrollers: simplicity of deployment, secure environment, rich analysis and reduced power consumption.



For more information, visit: <https://cartesiam.ai/>

Cartesiam is a member of the [Arm AI partner program](#).