



life.augmented

AI Solutions

Learning on STM32 with Cartesian: for equipment monitoring and more

October 13th, 2020


CARTESIAM.AI


STM32
Cube.AI

Learning on STM32 with Cartesiam

- 1 Condition Monitoring at the edge
- 2 Cartesiam and ST offers
- 3 Use cases and applications
- 4 Expand with STM32Cube.AI and connectivity
- 5 Q&A

Condition Monitoring at the edge

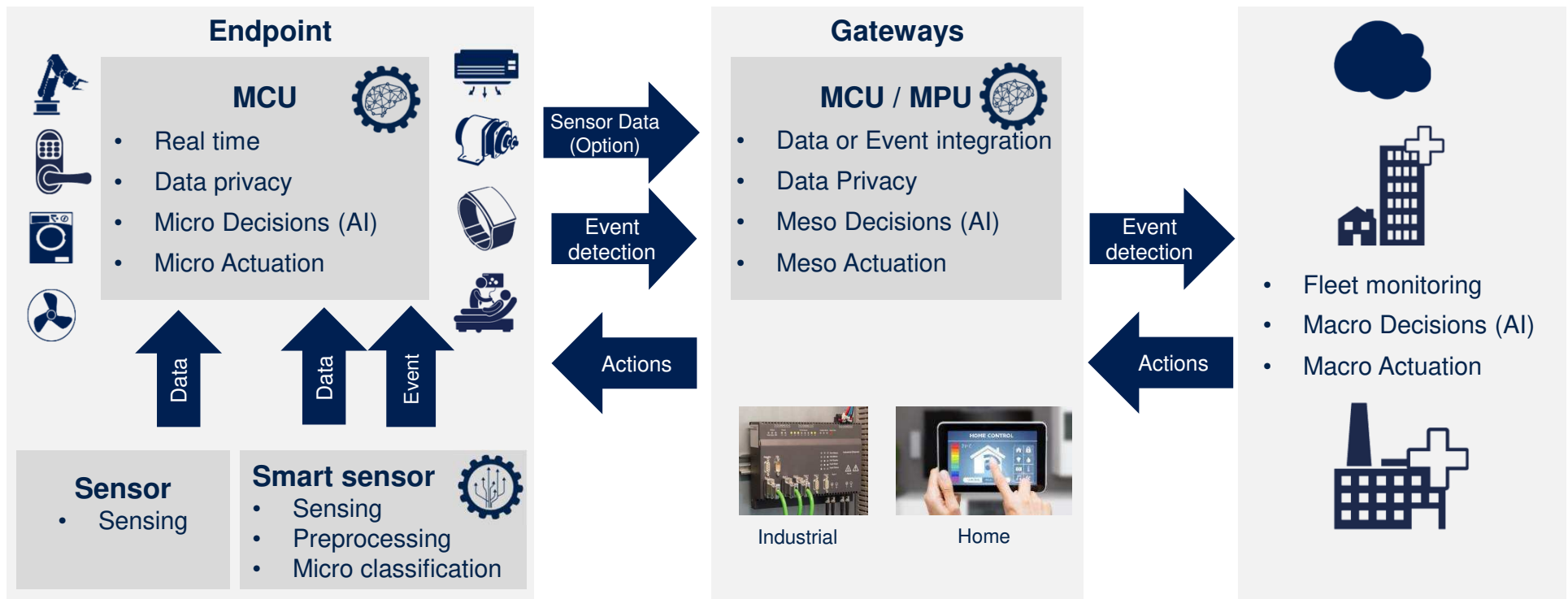


Distributed AI from Edge to Cloud

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Edge

Cloud

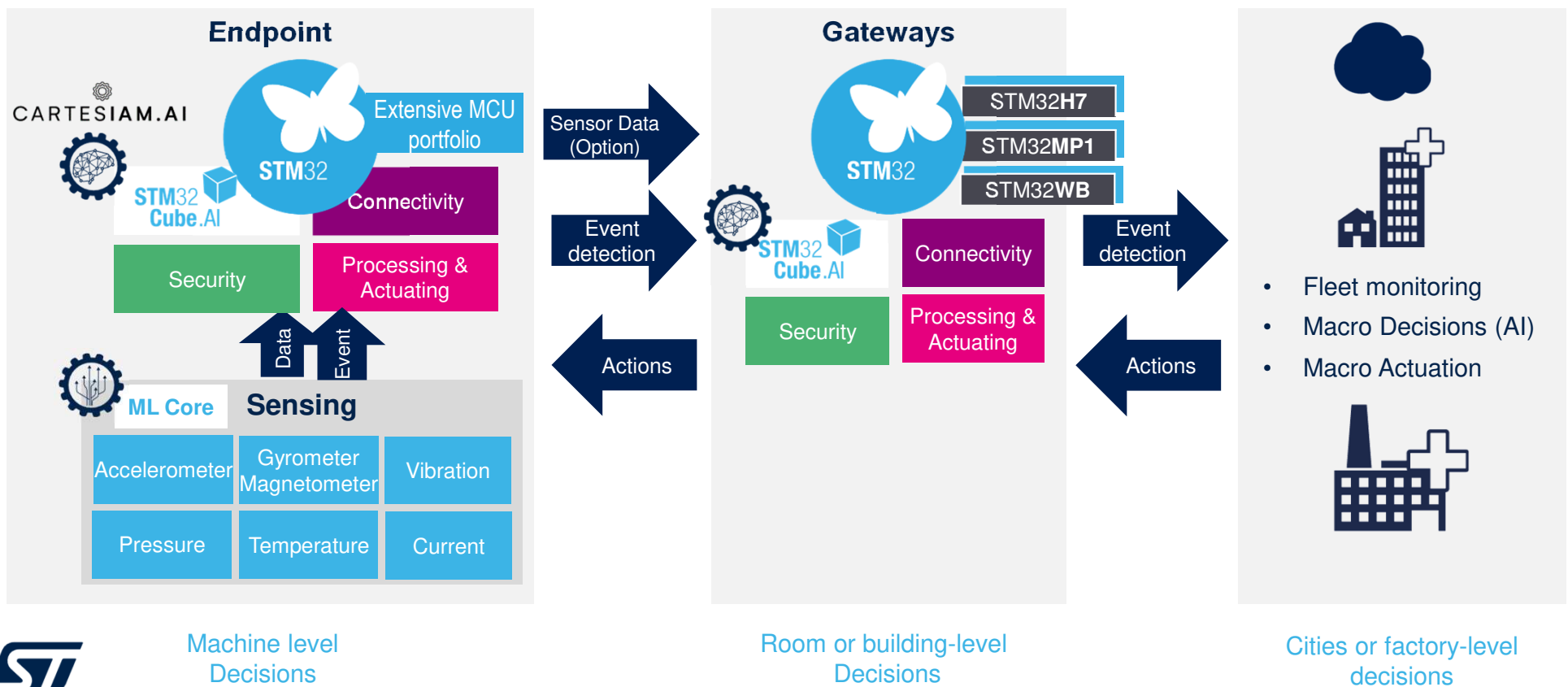


Distributed AI from Edge to Cloud

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Edge

Cloud



Benefits of AI inferencing and learning at the Edge

Realtime / low latency



No privacy issue



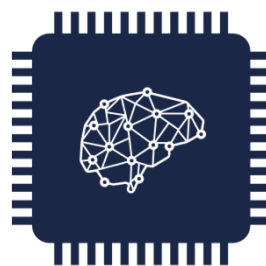
Better user experience



Reliable to connectivity loss



Optimized cloud usage



No need for large dataset collection



Adapt to local conditions

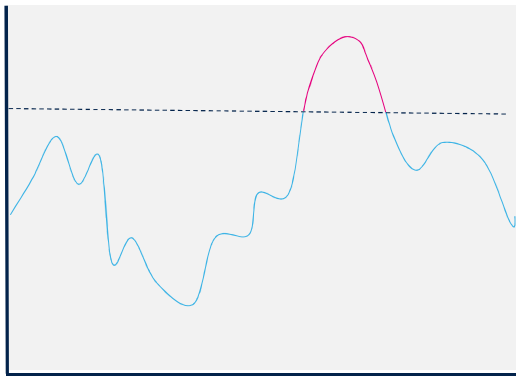


No need for extensive data scientist work



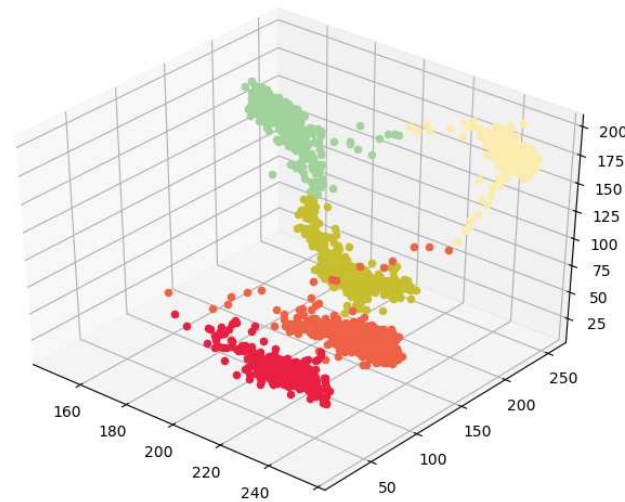
Benefits of AI vs traditional approach

7



Handcrafted rule based on
experience in the field

Procedural programming

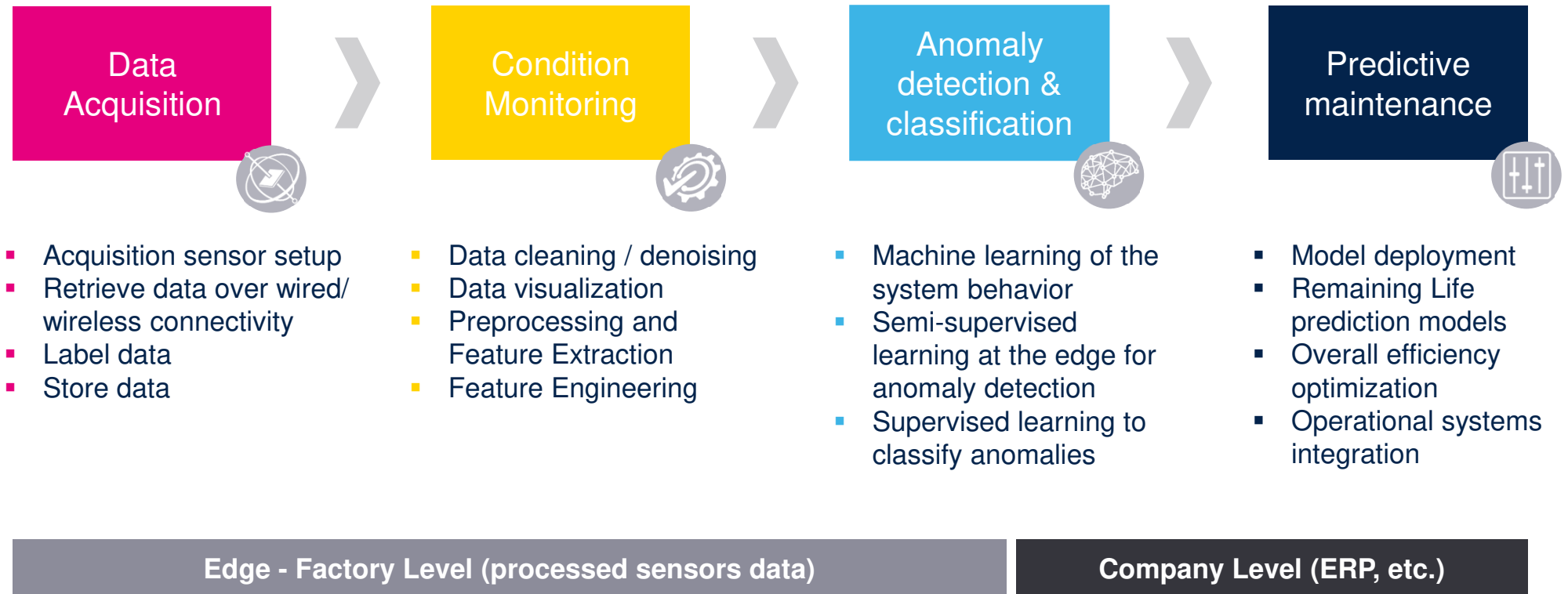


Rules learnt automatically
from base of data

Learn from example

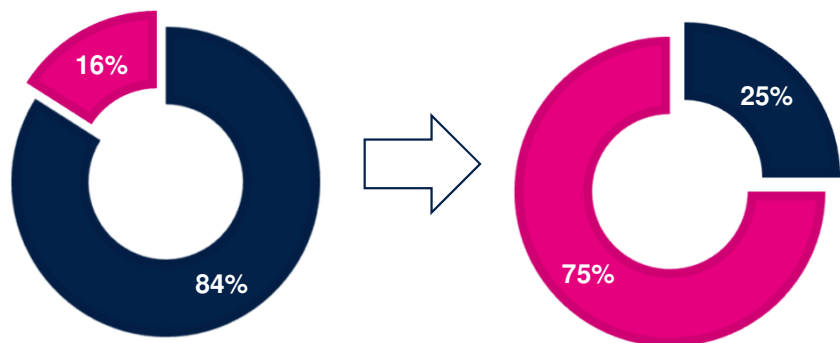
Steps to a predictive maintenance system

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Jump-start a predictive maintenance program

84% of surveyed companies
interested to develop
Predictive Maintenance



...but 25% started to
implement

The challenges

- Data collection, cleaning and labelling
- IT security / infrastructure
- Lack skilled data scientists and embedded developers
- High investment cost
- Bridge gap between OT/IT teams

What we need today

- Algorithms relying on smaller dataset
- Learning at the edge
- Solutions to integrate Machine Learning capabilities without deep AI knowledge

ST and Cartesiam offers



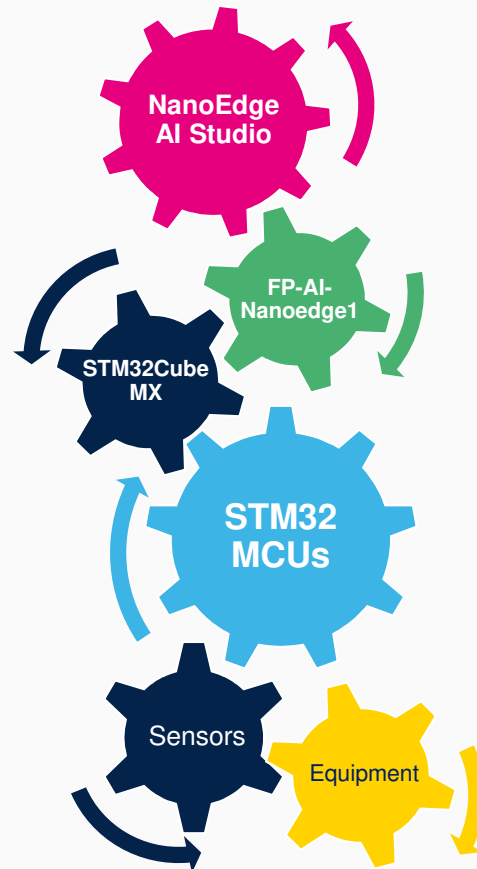
Authorized
Partner




FP-AI-NANOEDG1 with NanoEdge AI Studio

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Develop **ML-based condition monitoring solution** in a couple of hours and without any data science skill



NanoEdge AI studio from  CARTESIAM.AI allow you to generate **free libraries on ST board** such as **STEVAL-STWINKT1B** and **STM32L562E-DK**

NEW

FP-AI-NANOEDG1: code example demonstrating Cartesian library's integration into **STM32 ecosystem**

Run condition monitoring on all **STM32** portfolio

Select **sensor** adapted to your application to monitor vibration, current, temperature, etc



ST MCUs and sensors for condition monitoring

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MEMS & Sensors

Environmental



LPS22HH	High Accuracy – Compact Size Absolute Pressure Sensor
LPS27HHW LPS33HW	Water Resistant Absolute Pressure Sensor
STTS22H	Digital Temperature Sensor
STLM20	Analog Temperature Sensor

Vibration



IIS3DWB	Ultra Wide Bandwidth Accelerometer
ISM330DLC ISM330DHCX	Wide Bandwidth Accelerometer + Gyroscope
IIS2DH	Wide Bandwidth, Ultra-low-power Accelerometer
IIS2MDC	Low-Noise, Low Power Magnetometer

Acoustic



MP23ABS1TR	Analog Differential Microphone
IMP34DT05-A	Digital Top Port Microphone

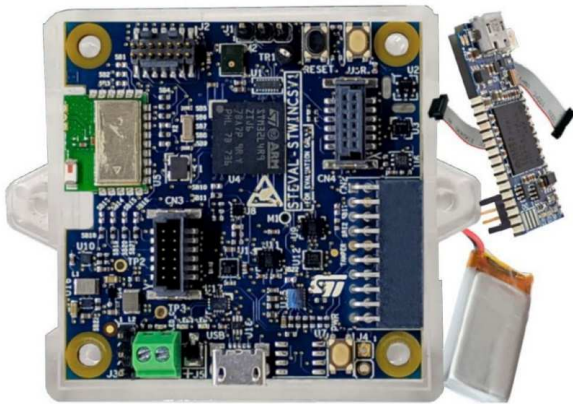


STM32 Ecosystem foundation

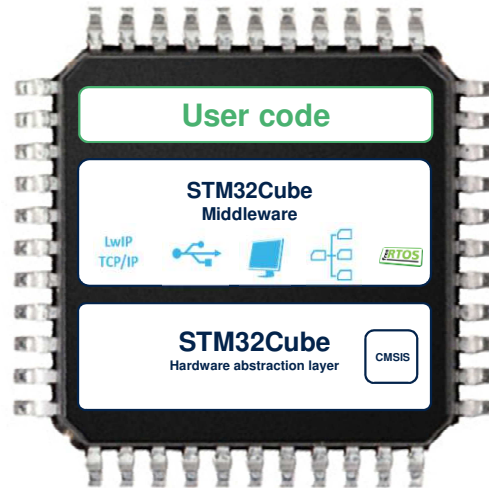
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Making it easy to start development, develop Proof of Concept

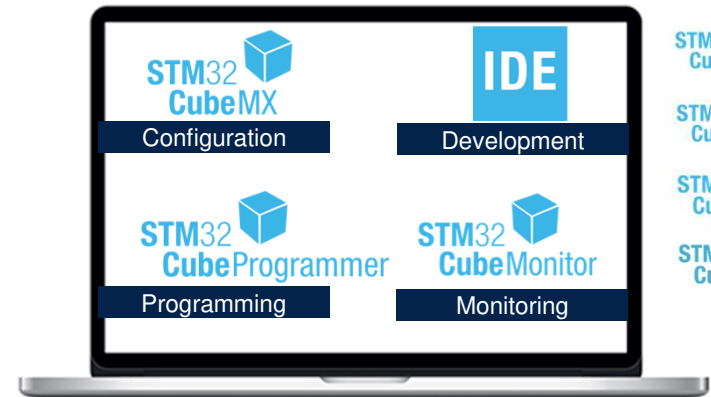
Hardware



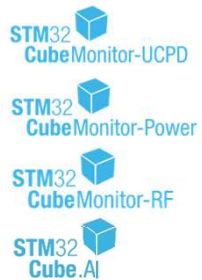
Firmware



Tools



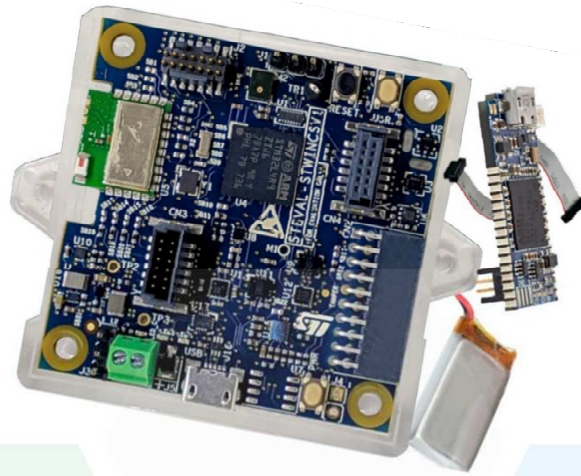
And more



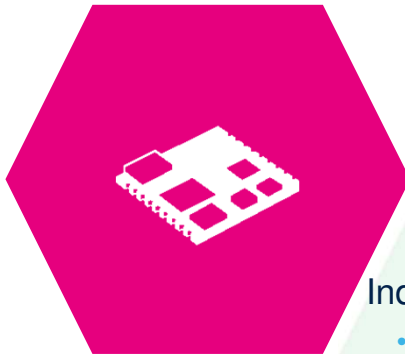
SensorTile Wireless Industrial Node

STEVAL-STWINKT1

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Capture data



Inference on STM32L4R9



Industrial-grade sensors

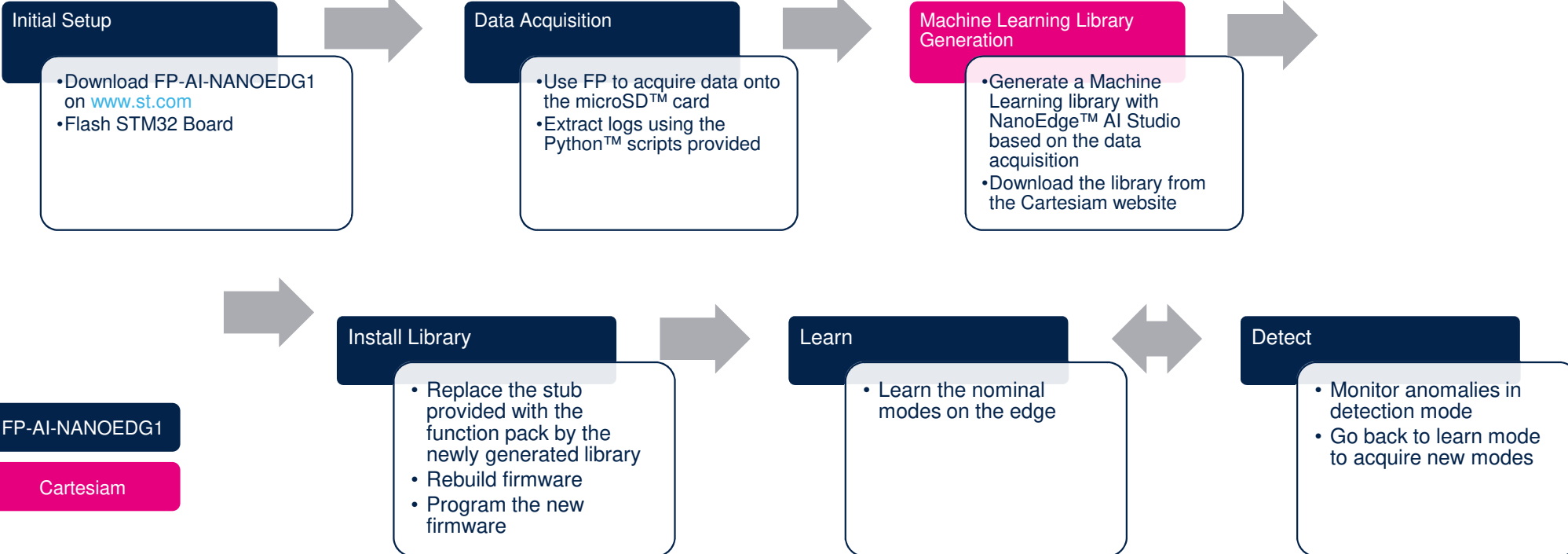
- Industrial scale 9-DoF motion sensors including accelerometer, gyrometer and an ultra wide-band vibrometer with ultra low noise
- Very high frequency audio and ultrasound microphone
- High precision temperature and environmental monitoring
- Micro SD card for standalone data logging
- BLE4.2 connectivity and WiFi expansion board
- USART

www.st.com/stwin



FP-AI-NANOEDG1

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NanoEdge AI Studio

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1

Describe your environment

Define RAM available
Define your sampling frequency
Define the sensor you want to use

2

Launch Platform

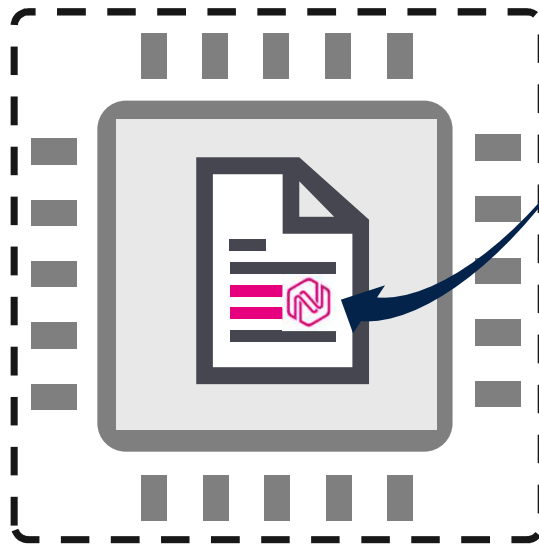
Wait few minutes to receive
your best optimized library
customized to your needs.

3

Integrate Library and Test

Download your library,
Embed it in your existing code
Test in your microcontroller

Signals



Microcontroller

Inference result



NANOEDGE AI by Cartesian

- The only commercially available solution bringing capabilities such as **LEARNING**, **UNDERSTANDING** and **ANALYZING** data directly into microcontrollers.
- A software component to easily and instantaneously bring AI software update to your solutions

Uses cases & applications



Monitoring using vibration sensors

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Home Appliance monitoring

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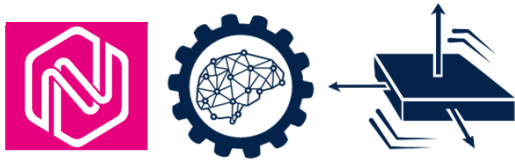
Problem

- Reduce unexpected failure and allow post-sales customer service to plan maintenance
- A home appliance leader want to upgrades its offerings to improve level of service

Solution

- State and environment have been learnt with FP-AI-NANOEDGE function pack, an obstructed pipes will generate abnormal vibration and will be detected and signaled





Leak Detection

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Problem

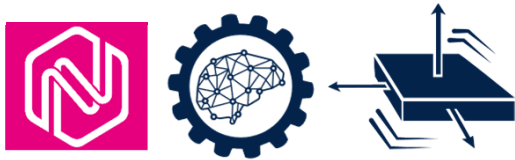
- Billions of gallons of water are wasted every year because of leakage.
- Consequence can be worst when there is a dangerous liquid or gaz leak

Solution

- Without changing any part in the HW design, embed a ML brick into STM32 MCUs that could identify leak with a 100% accuracy by monitoring pipes behaviors



Circuit breakers

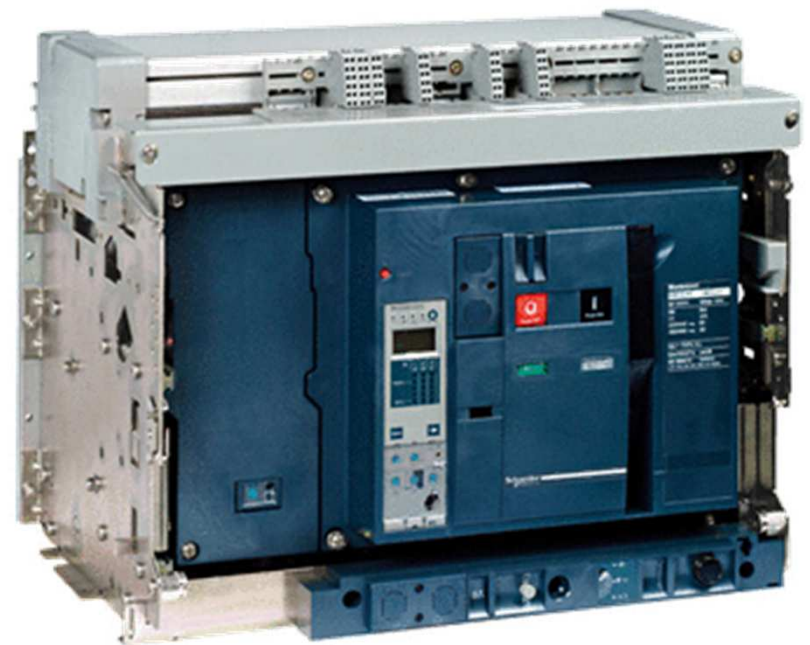


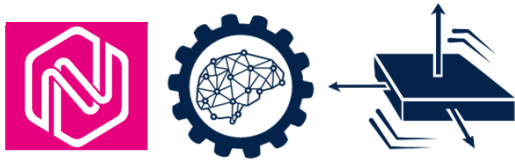
Problem

- The mechanical ageing of circuit breakers is virtually impossible to anticipate, leading to untimely power outages and costly production stoppages

Solution

- Circuit breaker aging can be analyzed from vibration patterns during switching
- NanoEdge AI solution has been successfully implemented inside circuit breaker to learn normal pattern of switch and help anticipate predictive maintenance





Reflow oven maintenance

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Problem

- Lacroix want to monitor reflow ovens condition, as xxx varies based on xxx

Solution

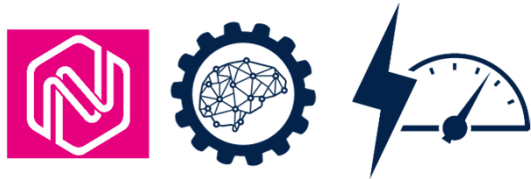
- The solution was developed in a few weeks and installed on external sensors.
- They immediately started to detect anomalies and had a solution up and running a few weeks after they started the project *by learning behaviour locally?*
- They estimate that they saved between 20 to 50 times in elapsed time and cost vs if they had to develop the same solution from scratch



Monitoring using current sensors

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Air conditioner filter monitoring

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Problem

- In an air conditioning system, it is very difficult to detect when a filter is clogged.
- The engineers had imagined installing cameras to film the colorimetry of the filters and compare it to a pre-learned model to detect when a filter was obstructed. They did not succeed.

Solution

- At the time of the first start-up of an air conditioner, NanoEdge AI learns the “shape” of the high-frequency directly inside the motor control card. No additional sensor is needed.
- When the filter is slightly obstructed, the shape of the high frequency current is alternated and detected by the NanoEdge AI library.





Elevator door monitoring

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Problem

- Doors are critical part of the elevator; issue can have serious impact on user or elevator itself
- however monitoring opening and closing over the time is not an easy task.

Solution

- Learn the opening / closing current pattern
NanoEdge AI learns directly inside the motor control card or adding an ammeter.
- When the current pattern is slightly different due to any source opposite force on the door, NanoEdge AI library running on STM32 will directly report an anomaly.



Expand with **STM32**  and connectivity



Teach your STM32 to classify anomalies with STM32Cube.AI tool

STM32Cube.AI offers interoperability with state-of-the-art Deep Learning design frameworks

Any framework that can export models in **ONNX** open format can be imported, including quantized models

Automatic and fast generation of an STM32-optimized library

On-device validation enable fast comparison of model accuracy vs different memory / quantization options

Train NN Model



Convert NN into optimized code for MCU



Process & analyze new data using trained NN

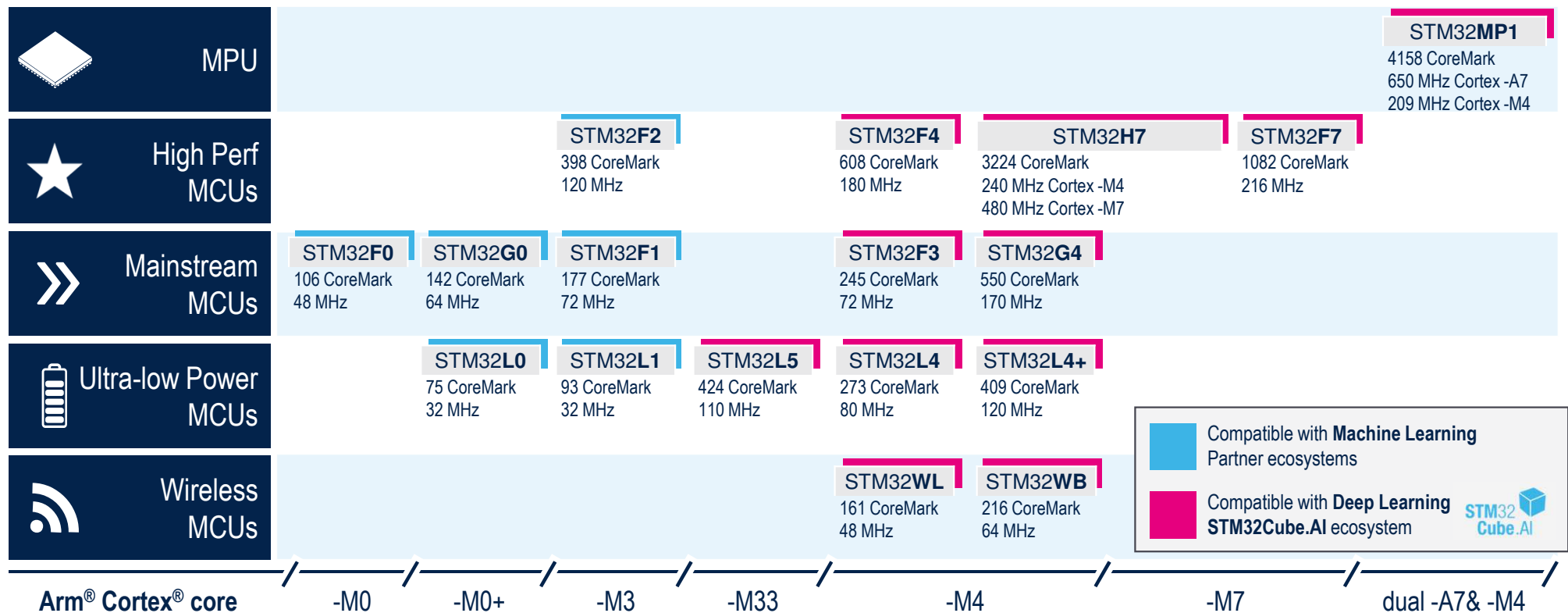




Making AI Accessible Now

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Leader in Arm® Cortex®-M 32-bit General Purpose MCU



Arm® Cortex® core

-M0

-M0+

-M3

-M33

-M4

-M7

dual -A7& -M4



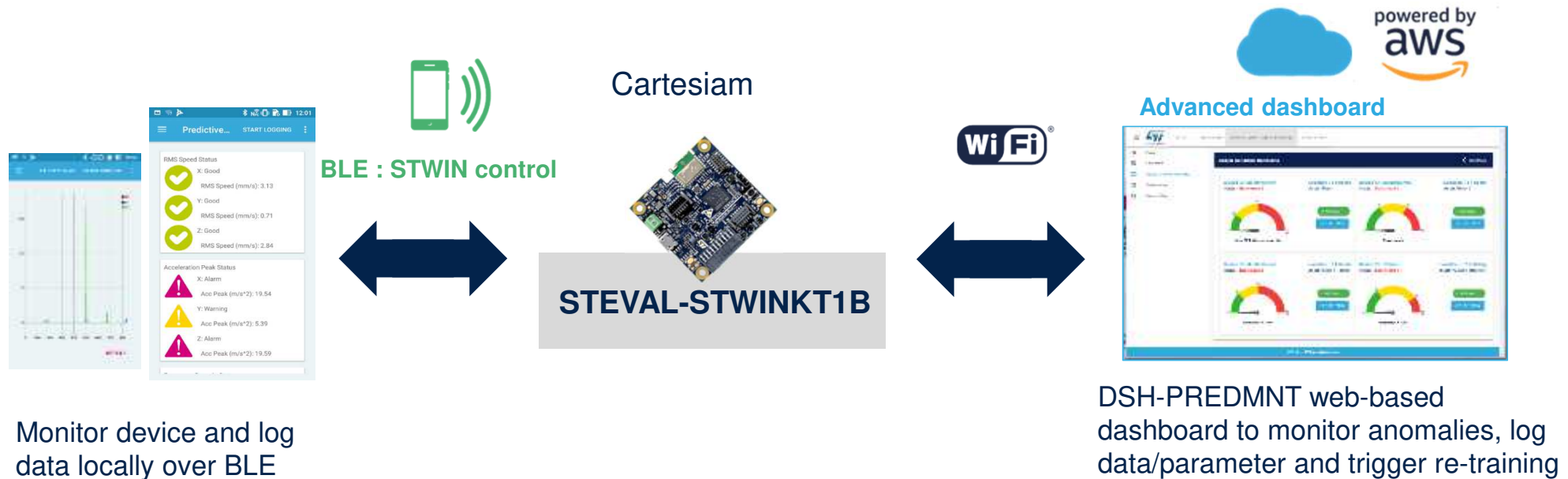
More than 40,000 customers

Over 4 Billion STM32 shipped since 2007

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Add connectivity with FP-IND-PREDMNT2

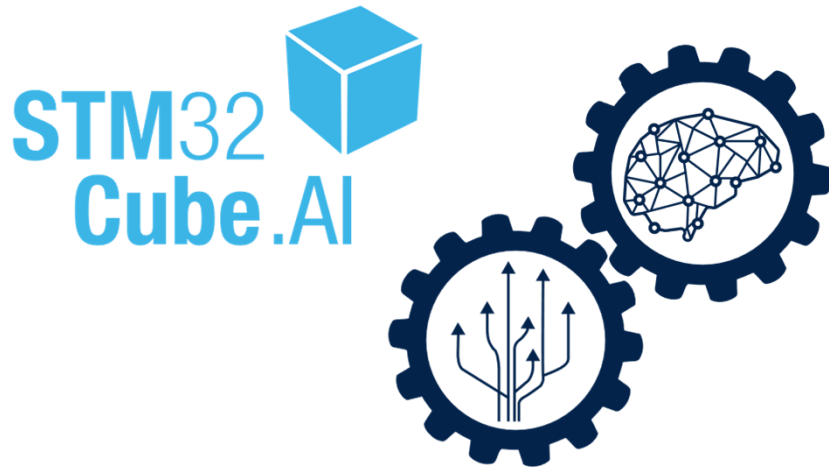
Take advantage of BLE and WIFI through application and dashboard



STM32 solutions for AI

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An extensive toolbox to support easy creation of your AI application



AI extension for STM32CubeMX
to **map pre-trained Neural Networks**



Software examples for Quick prototyping
Audio, Motion and Vision Function packs
On **ST development Hardware**



STM32 **Community** with dedicated
Neural Networks topic



Trainings, hands on, MOOCs and
partners **videos**



STM32 AI Partner Program
with dedicated Partners providing
Machine or Deep Learning engineering services

For more information



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