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# AI solutions

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# What is AI?

## The evolution of AI

### Artificial Intelligence (AI)

Early Artificial Intelligence stirs excitement



### Machine Learning (ML)

Machine Learning begins to develop



### Deep Learning

Deep Learning breakthroughs drive AI boom



Any technique that enables computer to mimic **human behavior**

**Subset of AI.** Algorithms and methodologies that improve over time through **learning from data**

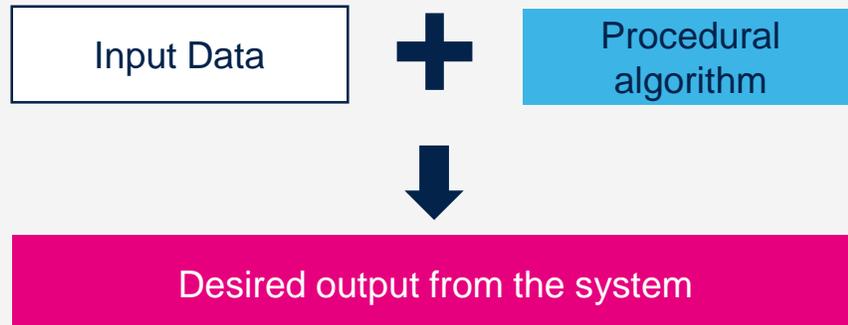
**Subset of ML.** Learning algorithms that derive meaning from a **huge amount of data**, by using a hierarchy of multiple layers that **mimic the neural networks of the human brain**

1950 1960 1970 1980 1990 2000 2010 2020

# A new way to add environment awareness to your products

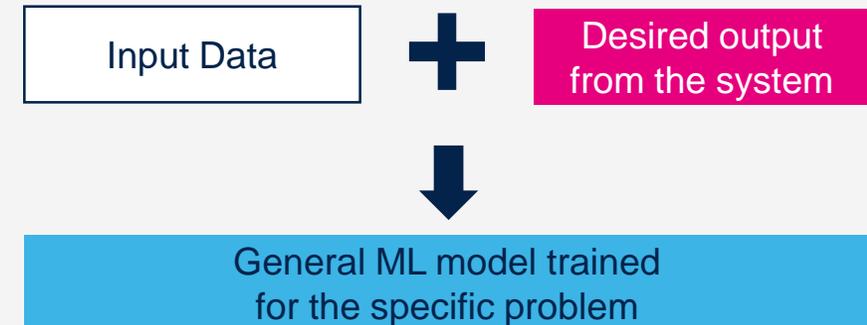
## Create more robust software using Machine Learning on STM32

### Standard programming Handcrafted rules based on experience



- Requires domain expertise to code
- Need to rewrite if environment evolves

### Machine Learning Rules learnt from real-world data



- Generate code from real-world observations
- Re-learn from data if environment evolves

# AI is used today in almost every market segment



**Drones**  
Flying & landing



**White goods**  
Smart control



**Smart Industry**  
Predictive maintenance



**Self-driving Cars**  
Environment sensing



**Smart Home**  
Event detection



**Smart Buildings**  
Energy saving



**Smart Farming**  
Optimizing conditions



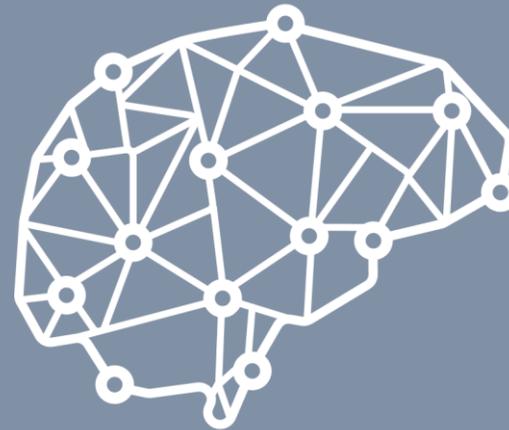
**Robots**  
Collision detection



**Personal Healthcare**  
Body measurements



**Personal electronics**  
Activity recognition

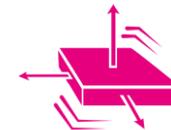
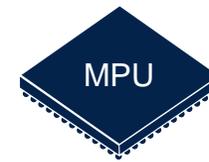
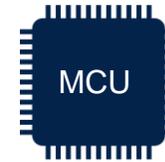


# Embedded AI technology trend

**“Global Shipments of Deep Edge AI Devices  
to Reach 2.5 Billion by 2030”**

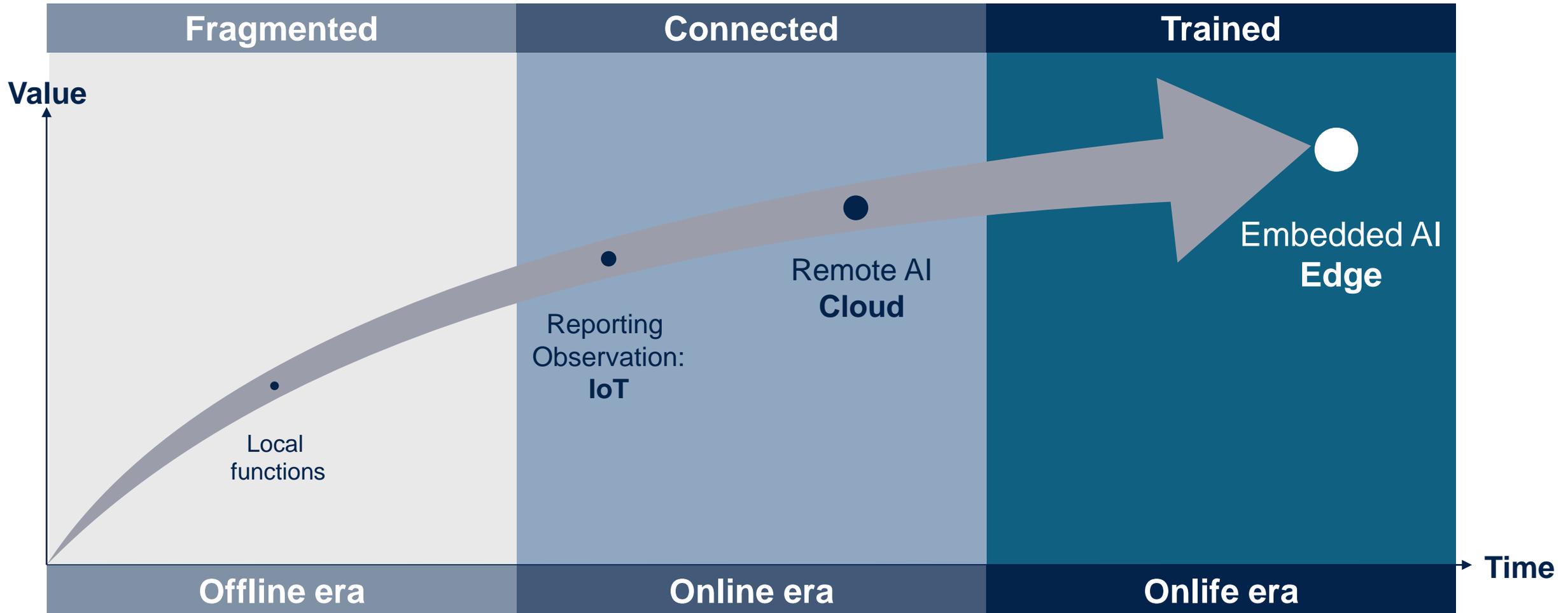
Source: [ABI Research](#)

AI technologies are now  
embedded inside end devices  
(MPU, MCU and sensors).



Growing community and ecosystem of **Deep Edge AI** technologies focusing on standalone, low-power and cost-efficient embedded solutions.

# The quest for an ever-SMARTER infrastructure



# Artificial intelligence at the Edge

Moving part of Artificial Intelligence closer to the data acquisition brings several benefits



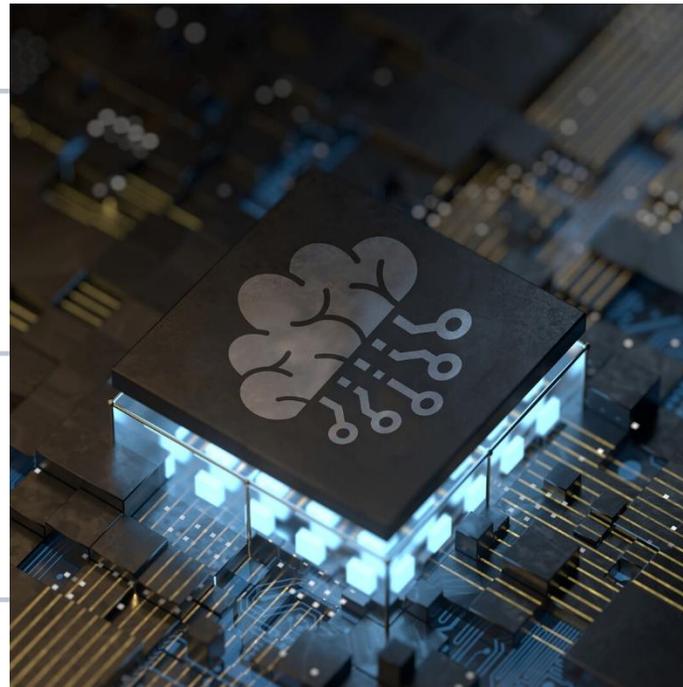
**Ultra-low latency**  
Real-time applications



**More reliability**



**Security of data**  
No sharing in the cloud



**Privacy by design**  
GDPR compliant



**Sustainable on energy**  
Low-power consumption



**Better user experience**

# A step too big to climb

## Organizations main challenges – AI Skills & datasets

### FAILURE RATE FOR AI.IOT PROJECTS

(Cisco Connected Research Futures)

74%

Lack of adequate data sets

15Months

Average time to collect & label data  
(Mc Kinsey)

Lack of data scientists

130,000

Data Scientist shortfall in the US  
(IBM Quant Crunch Report)

### EMBEDDED DEVELOPERS

(IDC)

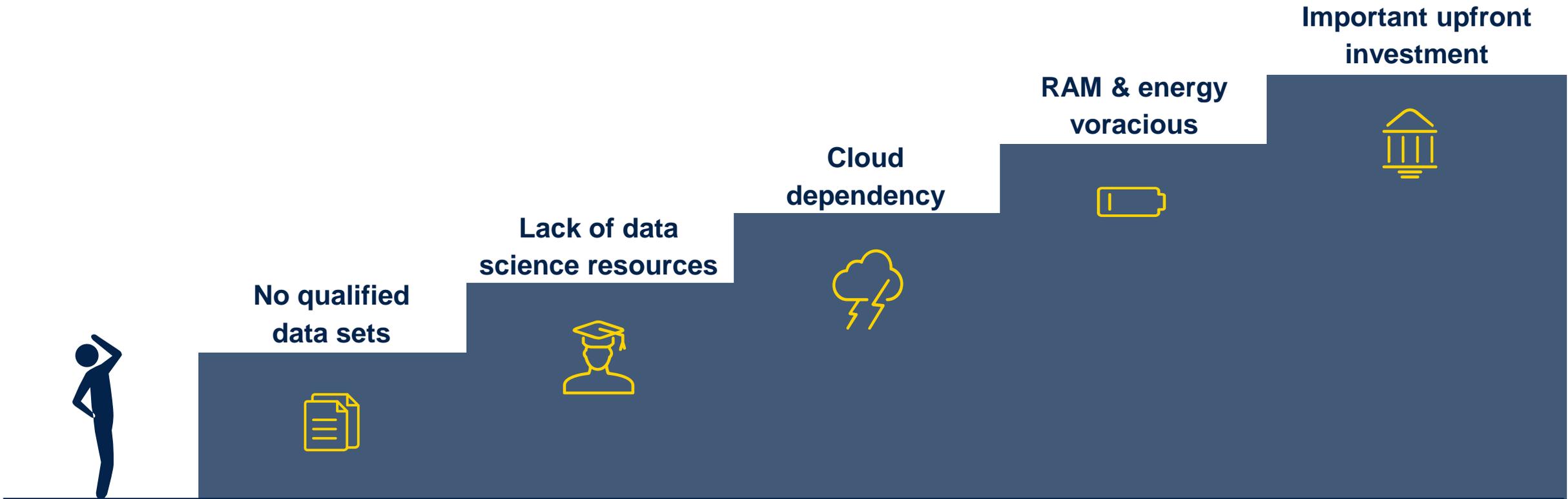
1.2Million

0.2%

With some AI skills

# For most companies, creating an edge AI device is a long journey with extraordinary challenges

Investment, complexity and development time are often barriers to AI adoption



**Start today with deep edge AI**

**“ If only  
I had solutions to overcome  
AI design challenges**

**THIS IS WHERE WE COME  
IN**



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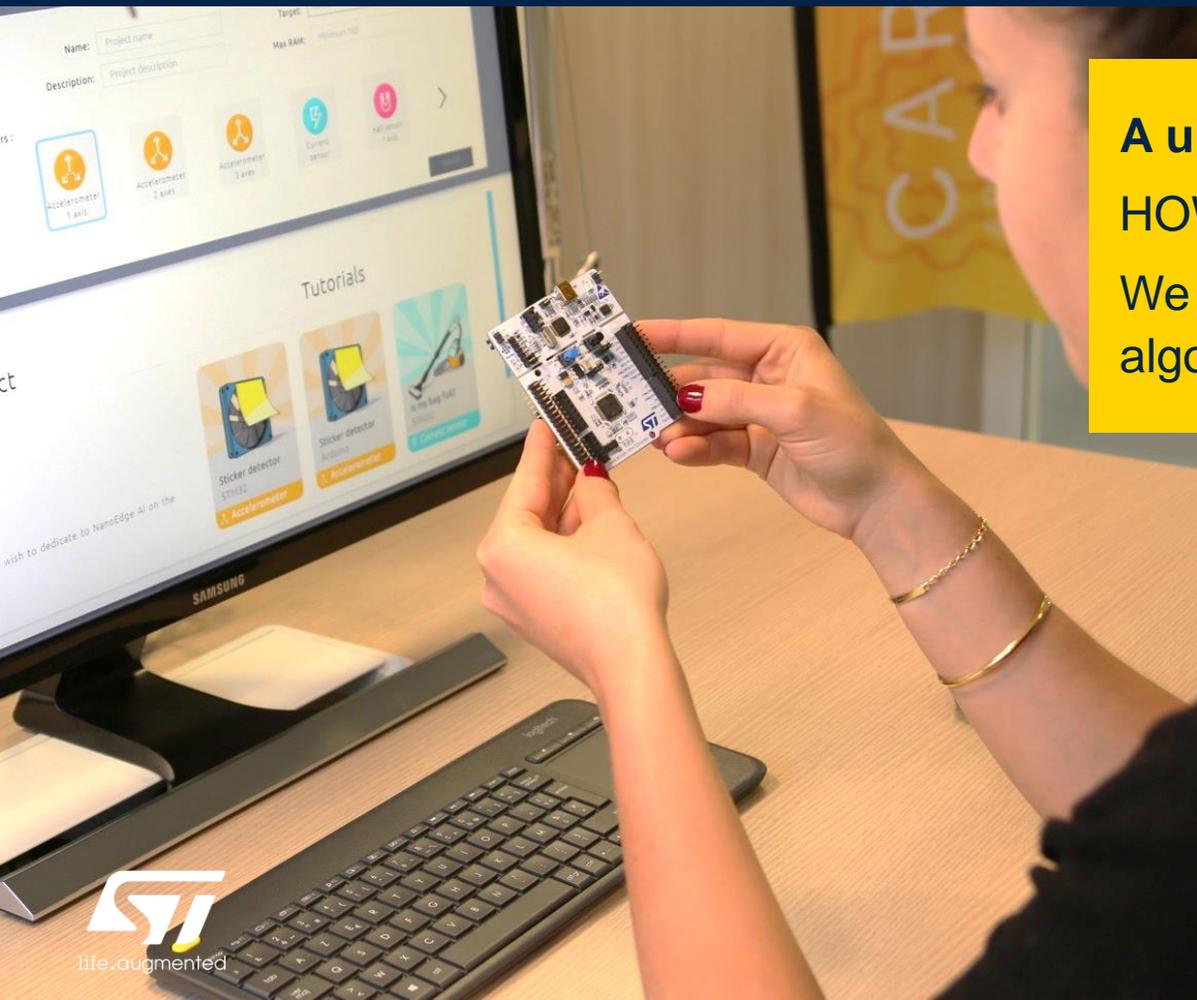
# Whatever your company's profile, you will find an AI solution suited to your needs

COMPANY'S PROFILE	USE CASES		
	Anomaly detection	Classification	Deep Learning
  <b>Embedded developers</b> <ul style="list-style-type: none"><li>No dataset available</li><li>No dedicated AI Team</li></ul>			 
  <b>Team with AI expertise</b> <ul style="list-style-type: none"><li>Dataset available</li><li>AI Team</li></ul>		 	

# For embedded developers

NanoEdge™ AI Studio, an automated ML design solution

NANOEDGE AI  
STUDIO 



**A unique solution thought from scratch**

**HOW DID WE DO IT?**

We re-wrote, from the algebra, ML and signal processing algorithms so that they can **LEARN** and **INFERR** inside STM32

- Patented technology
- Designed for embedded developers
- Ultra memory efficient (Flash and RAM)
- Unsupervised learning in the device
- No dataset need
- Superior security
- Small footprint, runs on any STM32 microcontroller
- Close to 100% accuracy and confidence
- For anomaly detection, classification and extrapolation problems

# For teams with AI expertise

STM32Cube.AI helps you accelerate your embedded development



## Easily evaluate, convert and deploy Machine Learning and Deep Neural Networks on STM32

An AI extension integrated with STM32Cube MCU development environment to **OPTIMIZE** and **TUNE** models, directly on target

- Develop and train your model with major AI frameworks



- Best ML performance on STM32 (MLPerf™ Tiny benchmarks)
- Validate performance directly on target
- Small footprint, runs on any STM32
- To address any kind of problem with ML or CNN libraries



# Making Edge AI accessible to all STM32 portfolio

**STM32Cube.AI & NanoEdge AI are compatible with all STM32 series**

 MPU

**STM32MP1**  
4158 CoreMark  
Up to 800 MHz Cortex -A7  
209 MHz Cortex -M4

 High Perf MCUs

<b>STM32F3</b> 245 CoreMark 72 MHz Cortex-M4	<b>STM32G4</b> 569 CoreMark 170 MHz Cortex-M4	<b>STM32F2</b> Up to 398 CoreMark 120 MHz Cortex-M3	<b>STM32F4</b> Up to 608 CoreMark 180 MHz Cortex-M4	<b>STM32F7</b> 1082 CoreMark 216 MHz Cortex-M7	<b>STM32H7</b> Up to 3224 CoreMark Up to 550 MHz Cortex -M7 240 MHz Cortex -M4
Optimized for mixed-signal Applications					

 Mainstream MCUs

<b>STM32F0</b> 106 CoreMark 48 MHz Cortex-M0	<b>STM32G0</b> 142 CoreMark 64 MHz Cortex-M0+	<b>STM32F1</b> 177 CoreMark 72 MHz Cortex-M3
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 Ultra-low Power MCUs

<b>STM32L0</b> 75 CoreMark 32 MHz Cortex-M0+	<b>STM32L1</b> 93 CoreMark 32 MHz Cortex-M3	<b>STM32L4</b> 273 CoreMark 80 MHz Cortex-M4	<b>STM32L4+</b> 409 CoreMark 120 MHz Cortex-M4	<b>STM32L5</b> 443 CoreMark 110 MHz Cortex-M33	<b>STM32U5</b> 651 CoreMark 160 MHz Cortex-M33
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 Wireless MCUs

<b>STM32WL</b> 162 CoreMark 48 MHz Cortex-M4 48 MHz Cortex-M0+	<b>STM32WB</b> 216 CoreMark 64 MHz Cortex-M4 32 MHz Cortex-M0+
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 Latest product generation

# Integrate your ML models more easily with our application-oriented code examples

## Time series-based monitoring



### FP-AI-MONITOR1

- Predictive maintenance and much more sensor-monitoring apps
- Runs Libraries from NanoEdge™ AI Studio

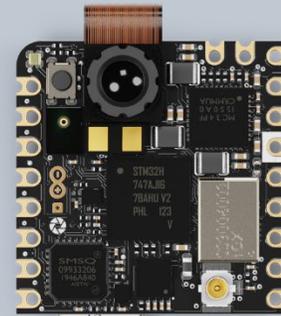
## Audio and Sensing



### FP-AI-SENSING1

- Human Activity Recognition
- Acoustic Scene Classification
- Data logging, labeling and result on BLE applications

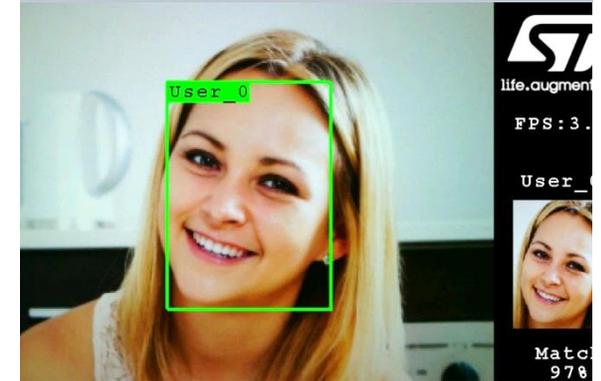
## Computer Vision



### FP-AI-VISION1

- Food recognition (CNN)
- Person presence detection (CNN)
- People counting (Object detection NN)
- Image processing Library

## Face recognition



### FP-AI-FACEREC1

- Face detection and recognition
- Fully functional without cloud connection

# We provide everything to kick off your project

## Design documentation



### Getting started

Be guided step-by-step to learn STM32 ecosystem

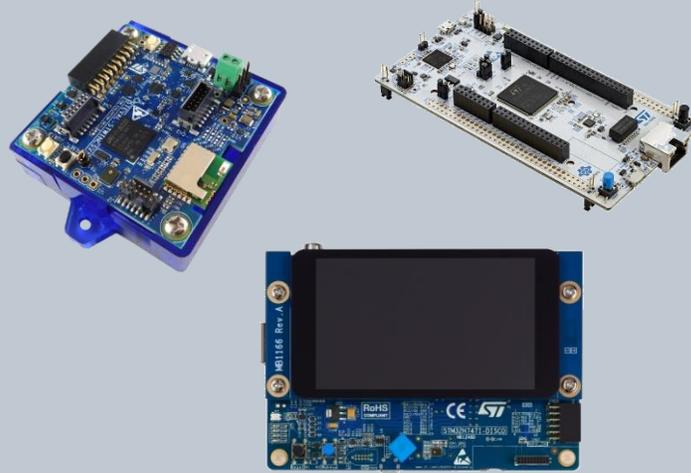


### Development zone

Get started on application development and project sharing

- **Wiki by ST** is a great forum to learn and start developing AI on STM32!
- Videos of application examples
- Massive Open Online Course (MOOC)

## Hardware and software tools



- Evaluation platforms for STM32 MCU/MPU
- Extra sensor boards
- Full software suite

## Support & Updates



- **ST Community:** STM32 ML & AI group
- Competence center
- Distributor certified FAE
- Support center
- Newsletter

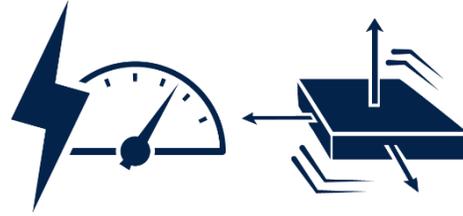
Stay focused on your expertise, we bring you everything else

# AI On The Edge - Uses Cases



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# Industrial maintenance Pump monitoring



## Problem

- Every pump has its unique signature according to pipe size, shape and mounting

## Solution

- Learn the pattern of every pump in operation and detect anomalies as they occur using vibration or current sensor
- When anomaly is detected the second library is activated to recognize the default (classification)

## Benefits

- Close to 100% accuracy due to local learning
- Extreme adaptability of model to wide range of pumps
- Ability to add seasonal learning phases



# Industrial maintenance Circuit breakers predictive maintenance



## Problem

- Mechanical aging of circuit breakers is virtually impossible to anticipate leading to
  - Unpredictable power outages
  - Costly production stoppage

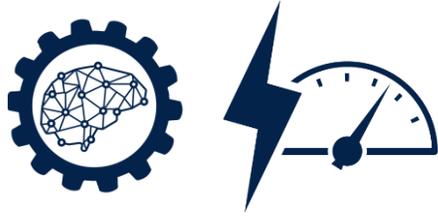
## Solution

- Circuit breaker ageing can be analyzed from vibration patterns during switching
- Vibration sensor learns normal pattern of switch and identify discrepancy to learned model



# Industrial maintenance Electrical arc detection

STM32  
Cube.AI



## Problem

- Solar panels are often damaged by electric arcs caused by impurities or physical damage
- This can lead to electric fire causing damage or endanger nearby people

## Solution

- Arc abnormal event can be identified by classifying arc fault features using ML or Neural Networks
- Local arc detection greatly increase reactivity to shut down the system, making panel safer and decreasing the amount of damage



# Building management Leak detection



## Problem

- Flush leaks represent millions of gallons of water wasted annually in hospitality industry
  - Threshold based sensors unable to avoid false positives
  - Thousands of different set ups requiring local learning

## Solution

- Vibration sensor learns normal pattern of flush and discern between leaks, ghost flushes and surrounding noises

## Benefits

- Ability to learn any flush automatically
- Only wakes up when an anomaly is detected



# Home appliance

## Air conditioner filter monitoring



### Problem

- In an air conditioning system, it is very difficult to detect when a filter is clogged
- 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 failed

### Solution

- Microcontroller learns the “shape” of the high-frequency directly inside the motor control card at the time of the first start-up of air conditioner
- No additional sensor is needed
- When the filter is slightly obstructed, the shape of the high frequency current is distorted and detected by the microcontroller



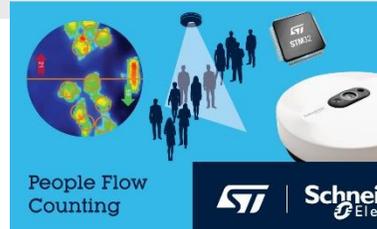


# ST co-development and partnerships

## Leverage the power of Edge AI

ST AI  
Expert  
team

AI co-development partnerships  
Contact us at [edge.ai@st.com](mailto:edge.ai@st.com)



Multiple Object Detection with Thermal Imager

Partner  
Program



Meet our expert AIS partners

Visit [https://www.st.com/content/st\\_com/en/partner/partner-program.html](https://www.st.com/content/st_com/en/partner/partner-program.html)



Predictive maintenance of reflow oven

<https://youtu.be/FjHfnwJdMEc>

[https://www.st.com/content/st\\_com/en/campaigns/artificial-intelligence-at-the-edge.html](https://www.st.com/content/st_com/en/campaigns/artificial-intelligence-at-the-edge.html)



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