



life.augmented

Artificial Intelligence Solutions



STM32 
Cube.AI



The key steps behind Neural Networks



Neural Network (NN) Model Creation



Operating Mode

Capture data



1

2



Clean, label data
Build NN topology

Train NN Model



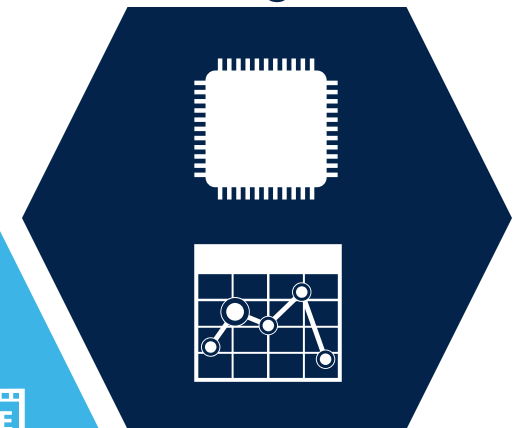
3

4



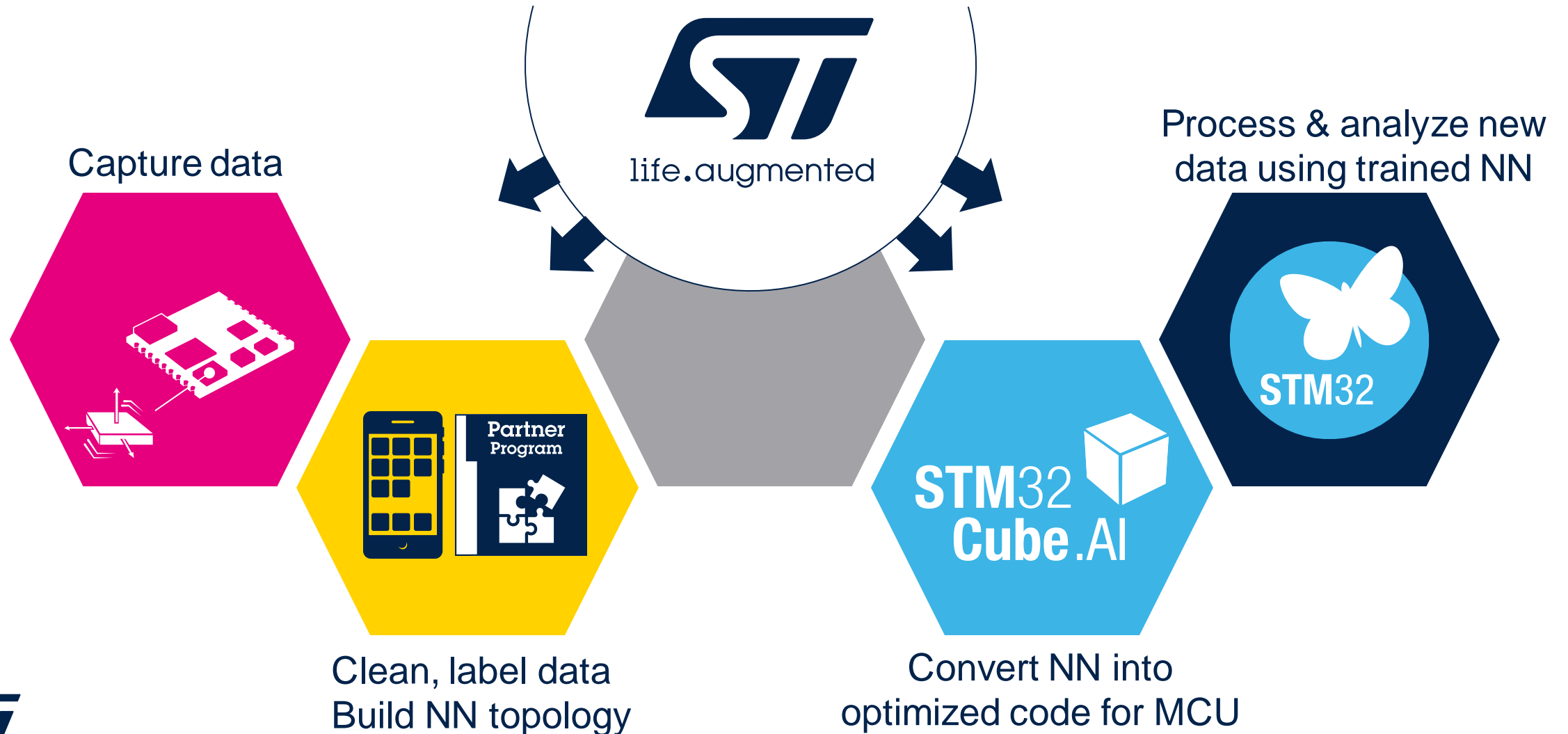
Convert NN into
optimized code for MCU

Process & analyze new
data using trained NN



5

ST toolbox for Neural Networks



STM32CubeMX extension AI conversion tool

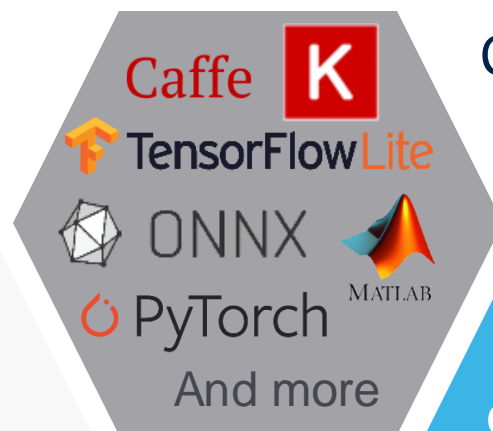
Input your framework-dependent, pre-trained Neural Network into the **STM32Cube.AI** conversion tool

Automatic and fast generation of an STM32-optimized library

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

Train NN Model



Convert NN into
optimized code
for MCU

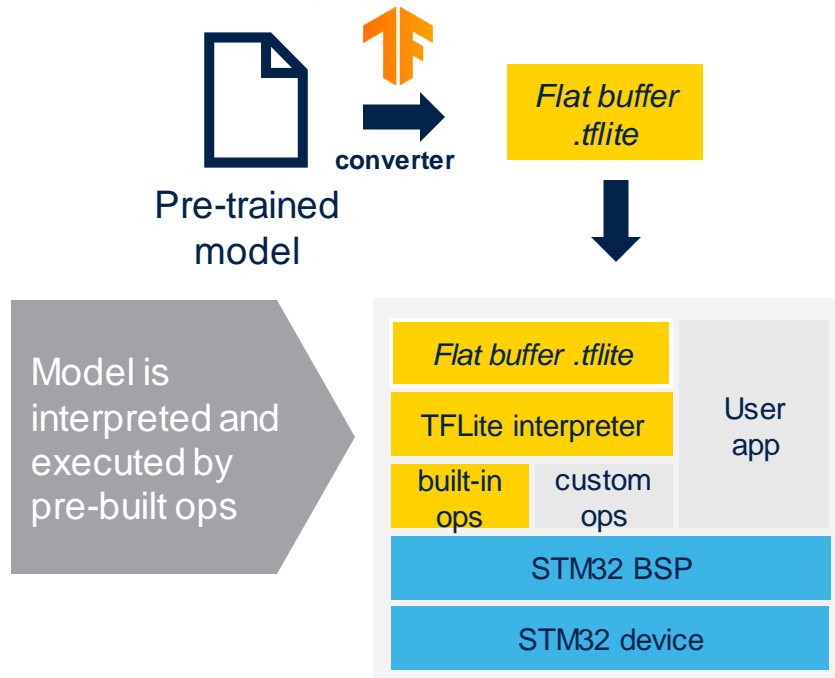


Process & analyze new
data using trained NN



Possible conversion strategies: Network code generation and interpreter

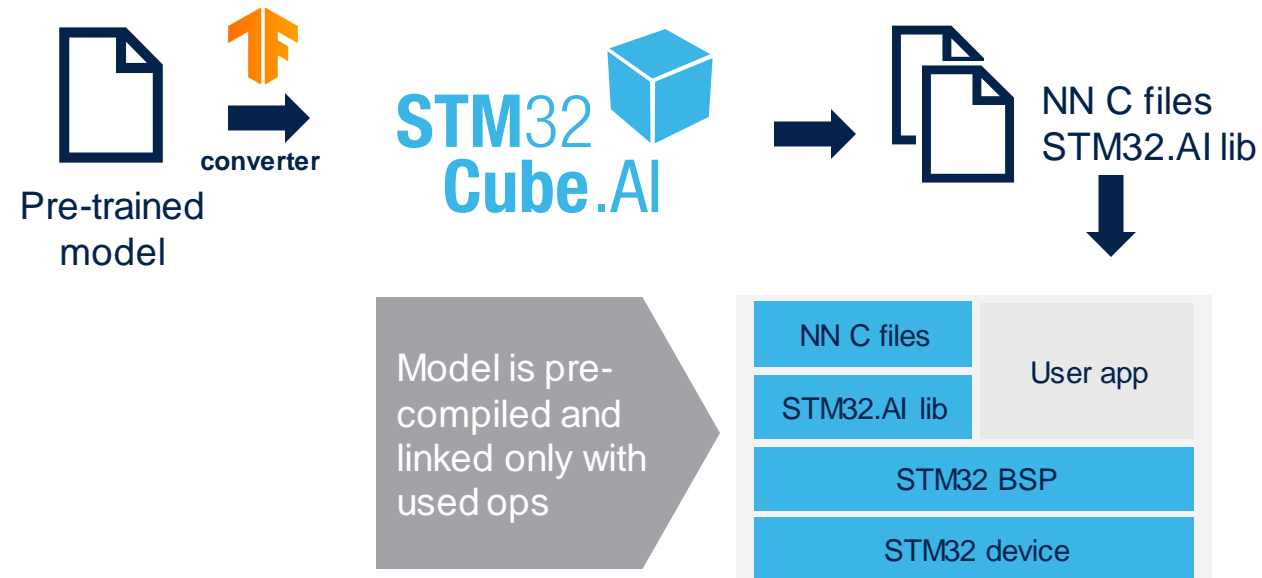
More Flexible:
TensorFlow Lite interpreter mode



 **TensorFlow Lite**
run-time on 

More optimized:
Optimized C code generated by

STM32
Cube.AI 



 **run-time**

Collecting data & architecting a NN topology

Services provided by Partners

ST tools to support

Capture data



Clean, label data
Build NN topology



ST BLE
Sensor

ST BLE Sensor mobile phone application

Collect and label data from the SensorTile.

Partner
Program



Selected partners

Neural Networks engineering services support.
Data scientists and Neural network architects.

ST toolbox for neural networks more than just a conversion tool



- Function packs for **quick prototyping**
- **Audio, Motion** and **Vision** examples



- STM32 **Community** with **dedicated** Neural Networks **topic**
- For **support** and **idea** exchange



Convert NN into
optimized code for MCU

Process & analyze new
data using trained NN

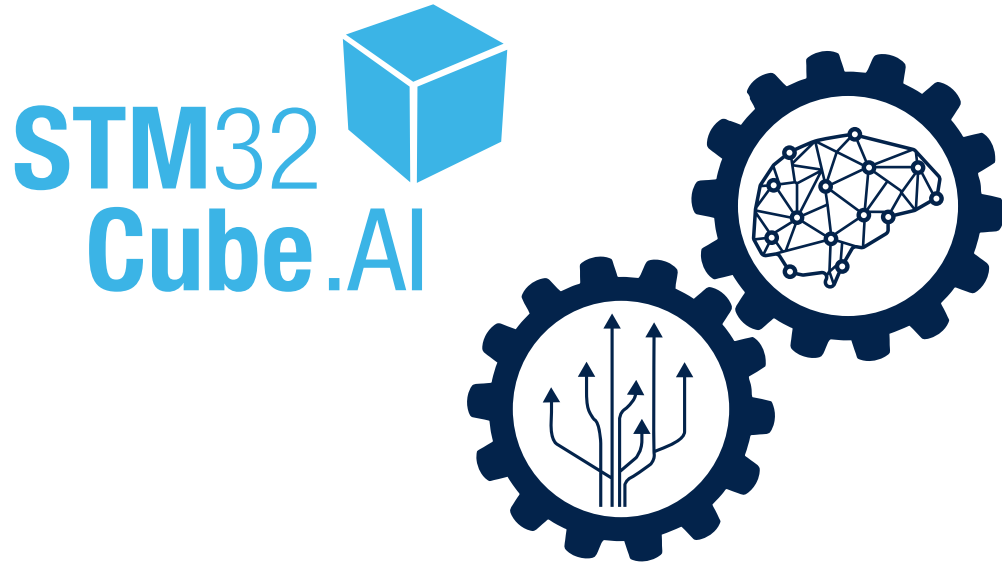




STM32 solutions for AI

More than just the STM32Cube.AI

An extensive toolbox to support easy creation of your AI application



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



1 2

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



1 2 3 4

STM32 **Community** with dedicated Neural Networks topic



1 2 3 4

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



1 2 3 4

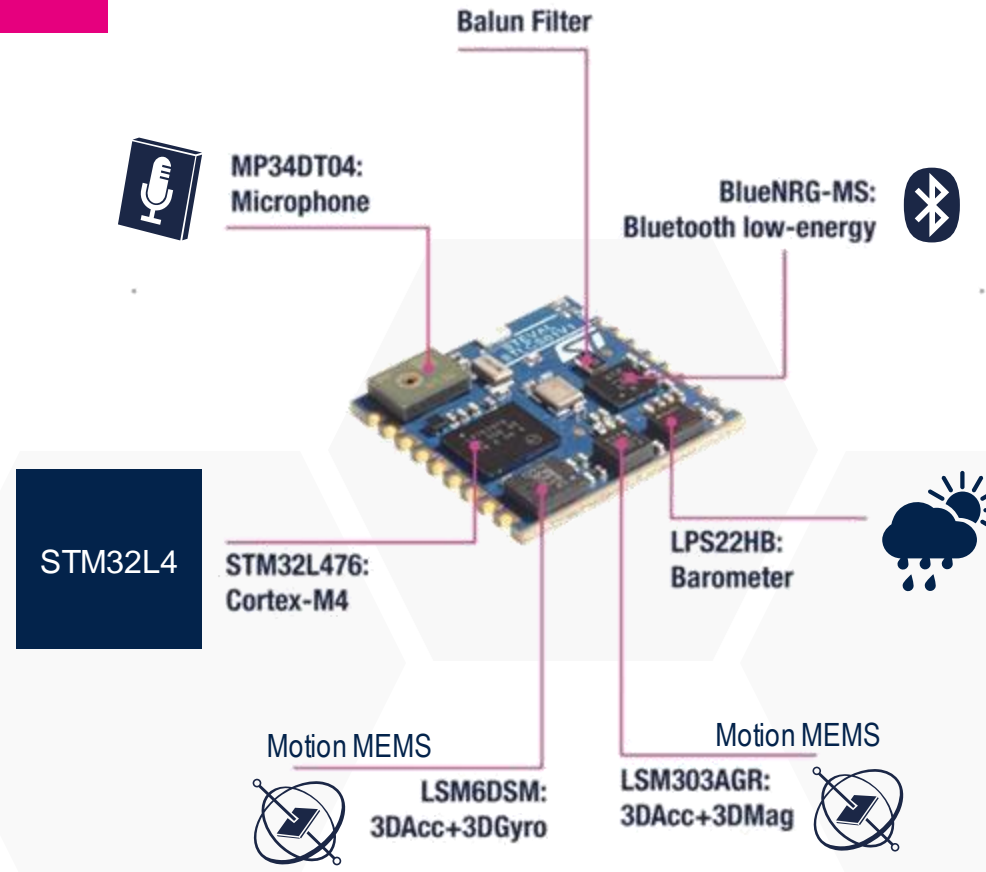
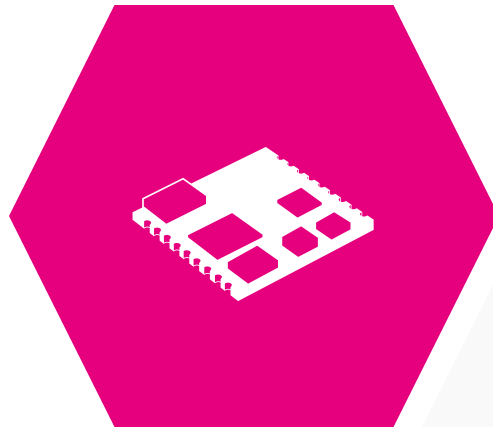
STM32 AI Partner Program with dedicated Partners providing **Machine or Deep Learning engineering services**



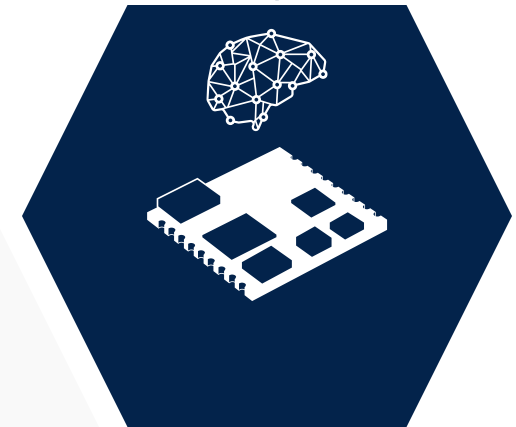
Example form factor hardware to capture and process data

SensorTile

Capture data



Process & analyze new data using trained NN

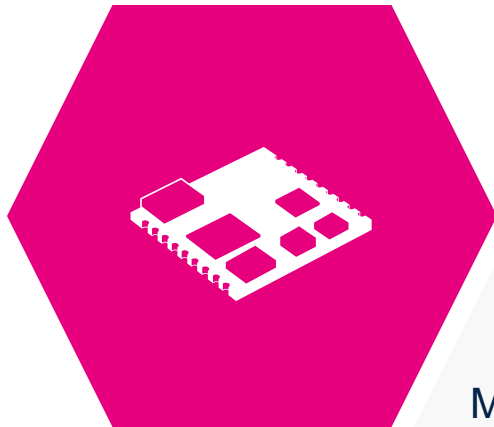




Fast go to market module to capture data with more accuracy

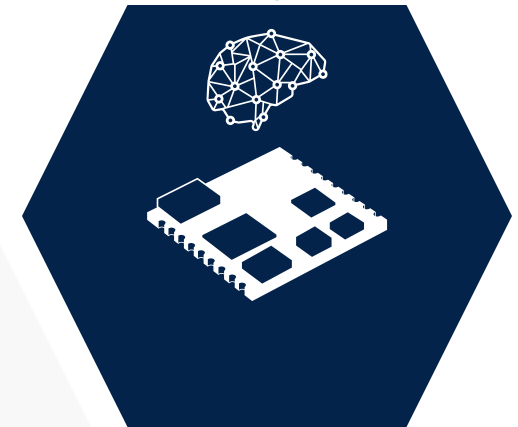
SensorTile.Box

Capture data



Microsoft IoT
Services ready
 Microsoft
Azure

Process & analyze new
data using trained NN



More advanced, high accuracy and low power sensors

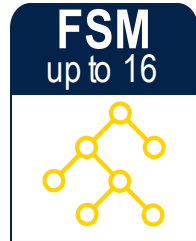
- First Inertial module with Machine Learning capabilities.
- Motion (accelerometer and gyroscope, magnetometer) and slow motion (inclinometer)
- Altitude (pressure), environment (pressure, temperature, humidity, compass) and sound (sound and ultrasound analog microphone)
- Microsoft IoT services ready to make available on a web dashboard the result of the embedded processing

www.st.com/SensorTileBox

Distributed AI: sensor + STM32

Optimize performance and power consumption

Smart Sensor with Machine Learning Core

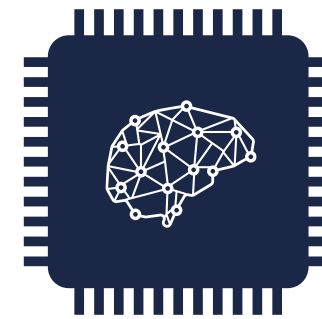


Raw Data

Event Decision

FSM and MLC
Re-configuration

Smart STM32 Second level of AI processing



Deep Learning
Neural Networks
Machine Learning

- Best ultra-low-power sensing at high performance
 - 550µA (gyroscope and accelerometer)
→ 200µA less than closest competitor
 - 20~40µA (Accelerometer only for HAR)
- Efficient Finite State Machines: 2µA
- Configurable Machine Learning Core: 4~8µA

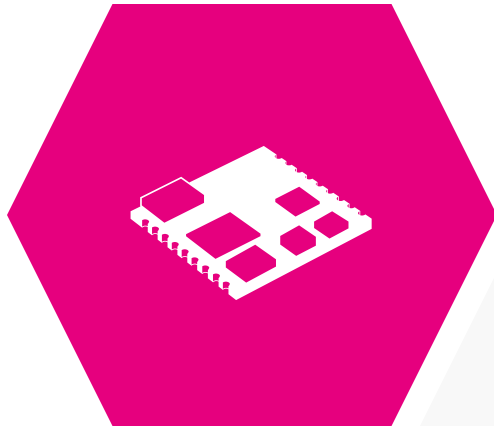
- More advanced and complex NNs
- Decisions on multiple sensors
- NN input can be sensor data and/or sensor Machine Learning decisions
- Multiple Neural Networks support
- Actuation & communication



Form factor hardware AI IoT node for more connectivity

IoTNode

Capture data



+

Sub
1GHz

Sub-1GHz

NFC

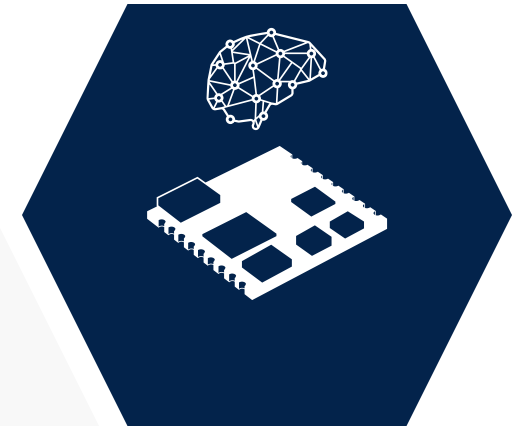
Dynamic NFC Tag

WiFi

Wi-Fi



Process & analyze new
data using trained NN



More debug capabilities

- Integrated ST-Link/V2.1
- PMOD extension connector
- Arduino Uno extension connectors



OpenMV integration

Fast machine vision prototyping

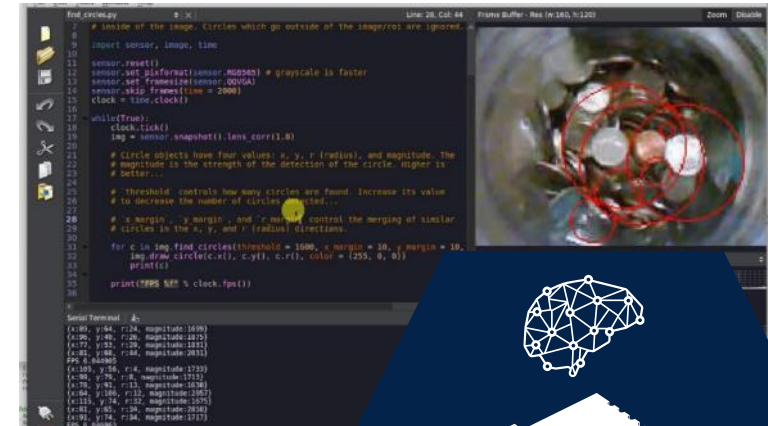


OpenMV CAM
Running MicroPython over STM32

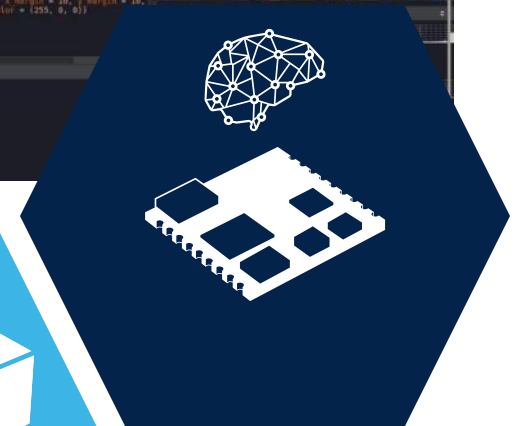
Configure Machine Vision in
real-time over USB in Python



Run and validate optimized
Neural Network



STM32
Cube.AI



Function Packs

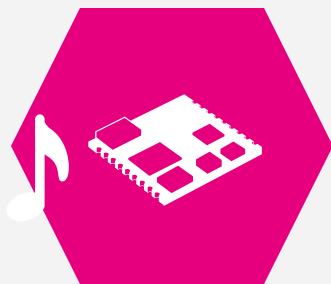
Simple, fast, optimized

STM32 
Cube.AI



Audio scene classification (ASC)

Audio example in FP-AI-SENSING1 package



Audio Data capture



Labelling controlled
by smartphone application

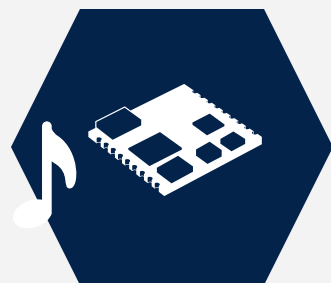


Data stored on the device
SD card for future learning

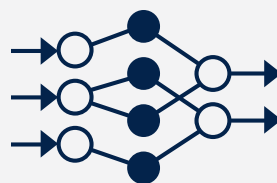


3 classes

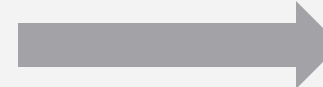
Indoor, Outdoor, In vehicle
labelling



Embedded audio
pre-processing



NN & example
dataset provided



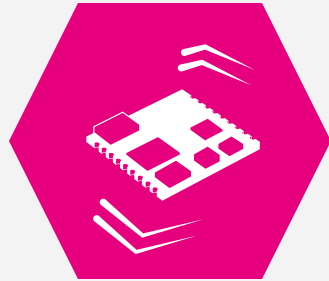
Inference result
displayed on mobile app





Human activity recognition (HAR)

Motion example in FP-AI-SENSING1 package



Motion Data Capture



Labelling controlled
by smartphone application

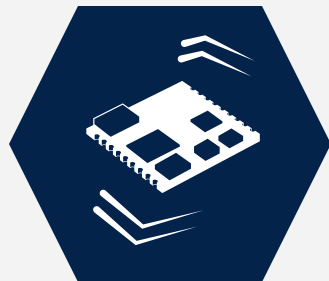


Data stored on the device
SD card for future **learning**

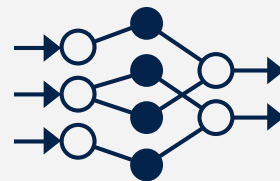


5 classes example

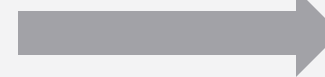
Stationary, walking, running,
biking, driving **labelling**



Embedded motion
pre-processing



NN & example
dataset provided



Inference result
displayed on mobile app





Image classification

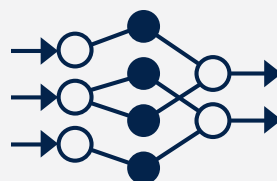
Vision example in FP-AI-VISION1 package

Enjoy the food classification demo

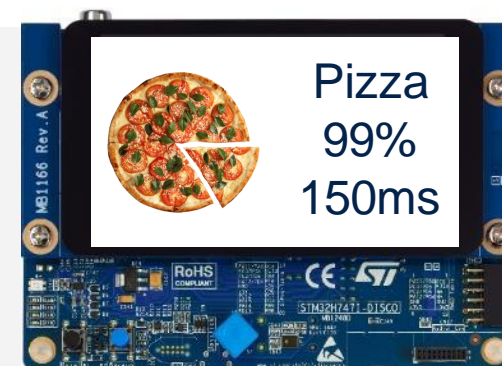
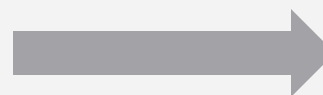
- Default demo based on 18 classes (224x224 RGB pictures)
- Several camera image output size possible

Full end-to-end optimized software example

- from camera acquisition to image pre-processing before feeding the NN
- Multiple memory mapping possibilities to optimize and test impact on performances
- Retrain this NN with your own dataset
- Quantize your trained network to optimized inference time and memory usage



NN & example dataset provided



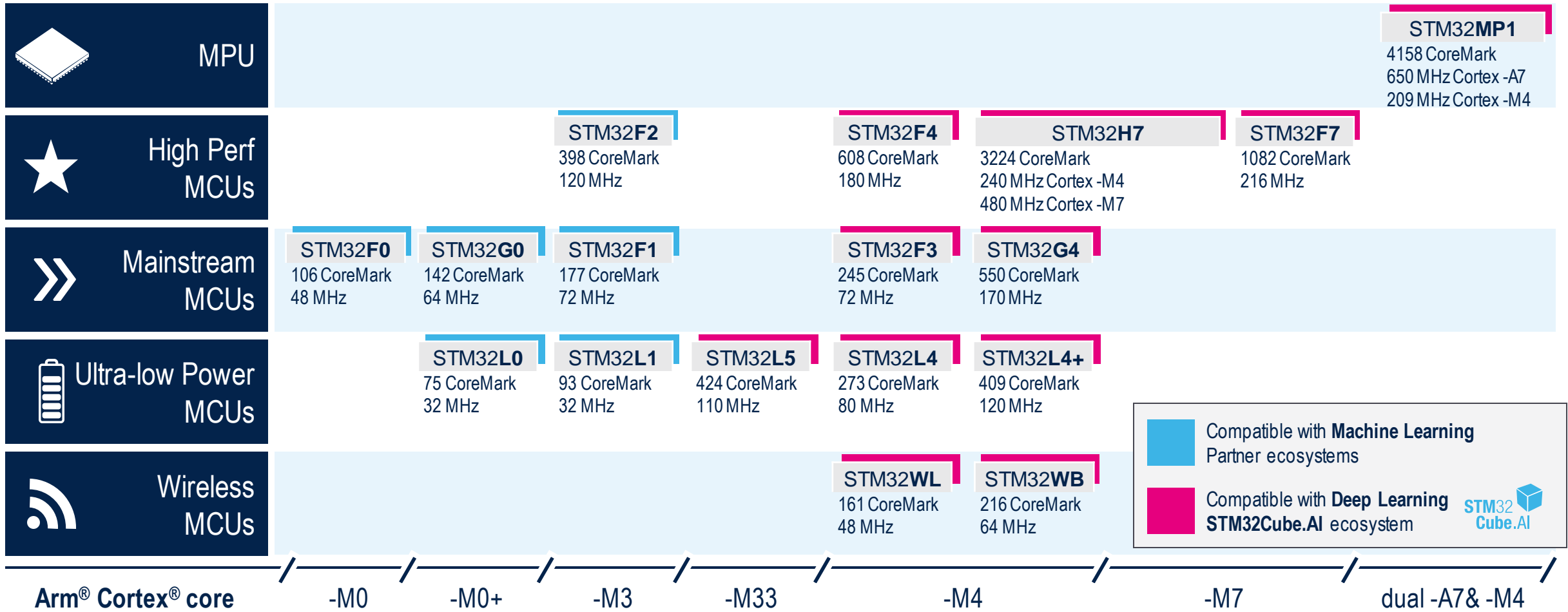
Embedded **image**
pre-processing (SW) on
the STM32H747

Inferences running
on the microcontroller



Making AI Accessible Now

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

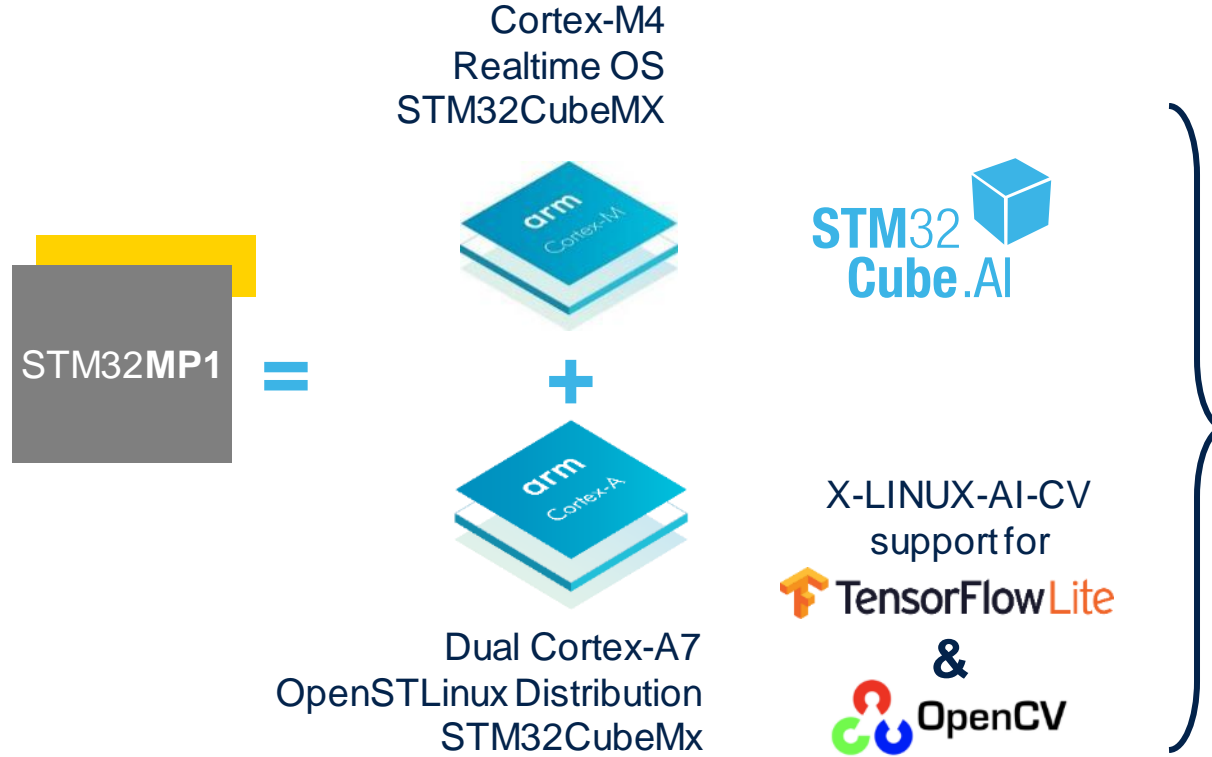
AI solutions for STM32MP1

Running AI on ST
Microprocessors

STM32 
Cube.AI



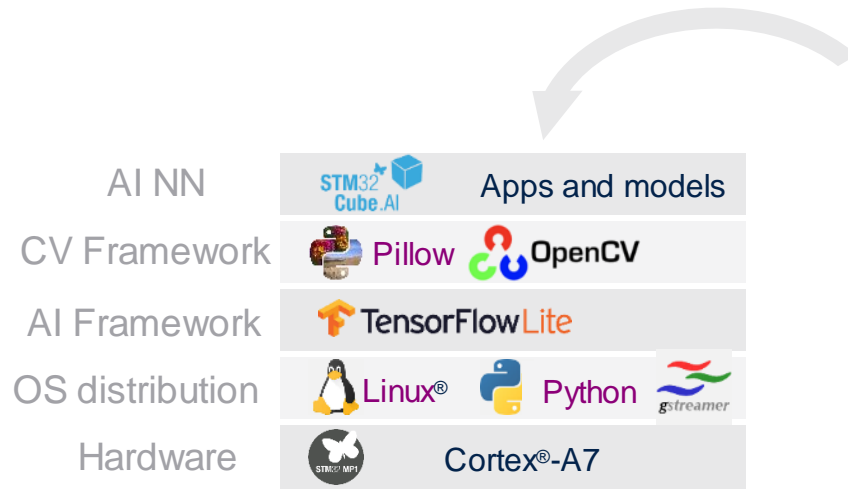
STM32MP1 microprocessor Augmented intelligence



- STM32Cube.AI to convert pre-trained NNs for the Cortex-M4 core
- TensorFlow Lite STM32MP1 support up streamed for native NN inferences support on the dual Cortex-A side



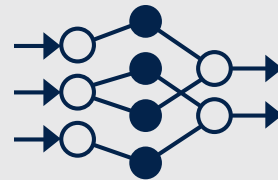
X-LINUX-AI-CV Package for STM32MP1 Computer Vision Application



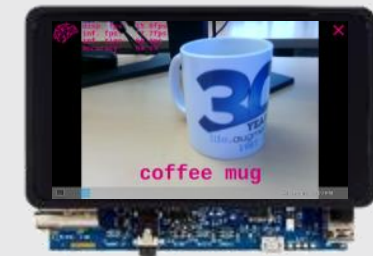
Application examples in C/C++ and Python

- Image classification: 1000 objects classified
- Multiple object detection: 90 classes

Includes code for camera acquisition and image pre-processing



AI, CV frameworks
& application
examples provided



USB camera or
built-in camera
module

Inferences running on the
microprocessor in 80ms
for image classification

Displayed on STM32MP1-DK2,
STM32MP1-EV1 and Avenger96 board

For more information



www.st.com/STM32CubeAI



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