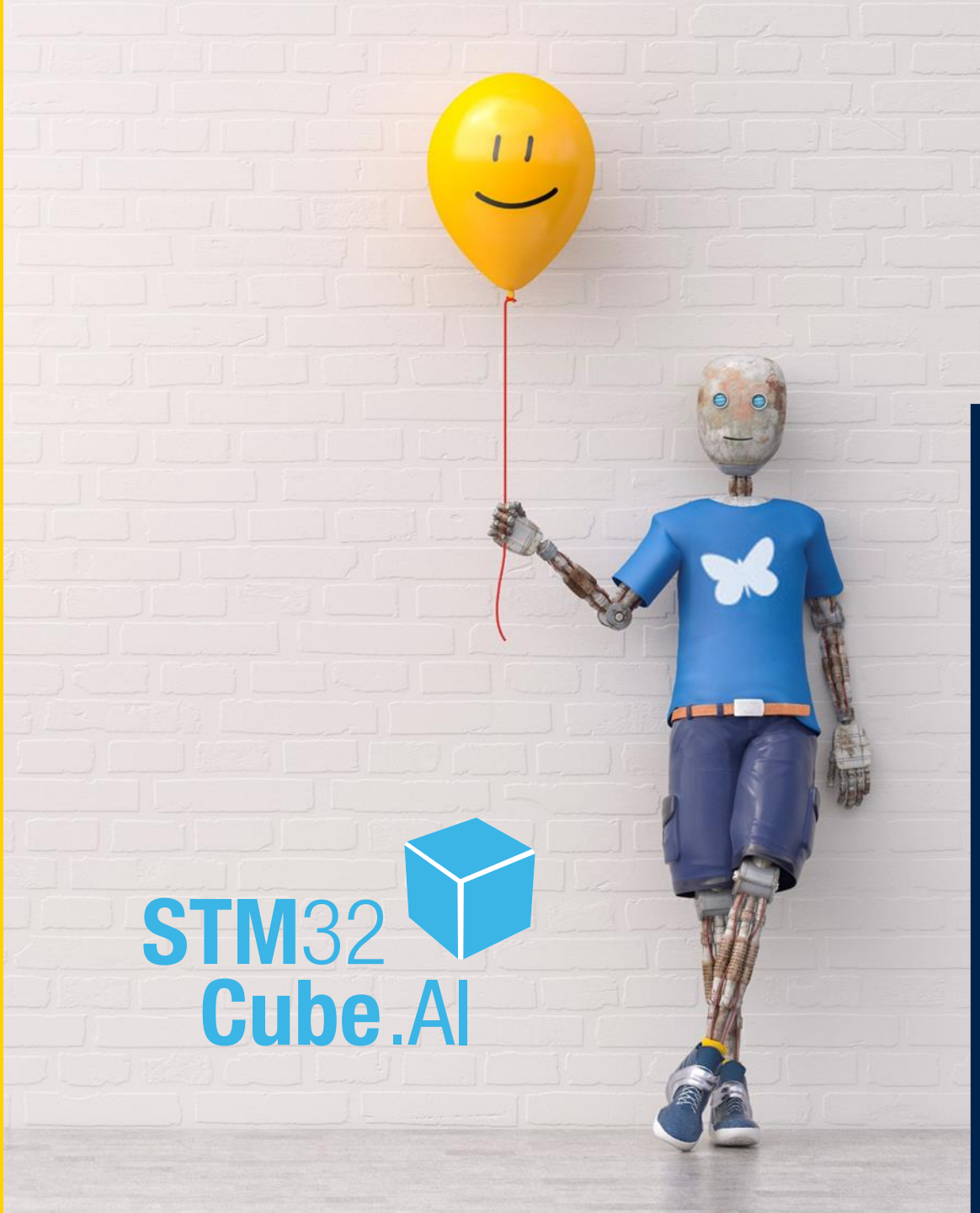

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Artificial Intelligence Solutions

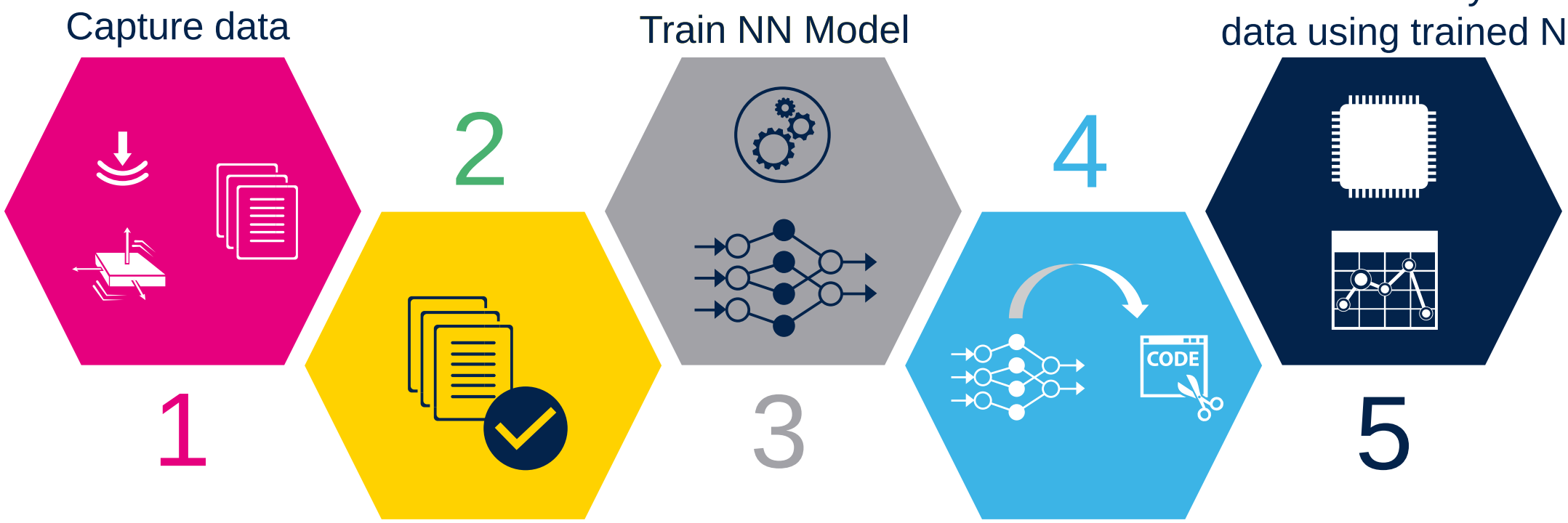
STM32 Cube.AI

STM32

The key steps behind Neural Networks

Neural Network (NN) Model Creation

Operating Mode



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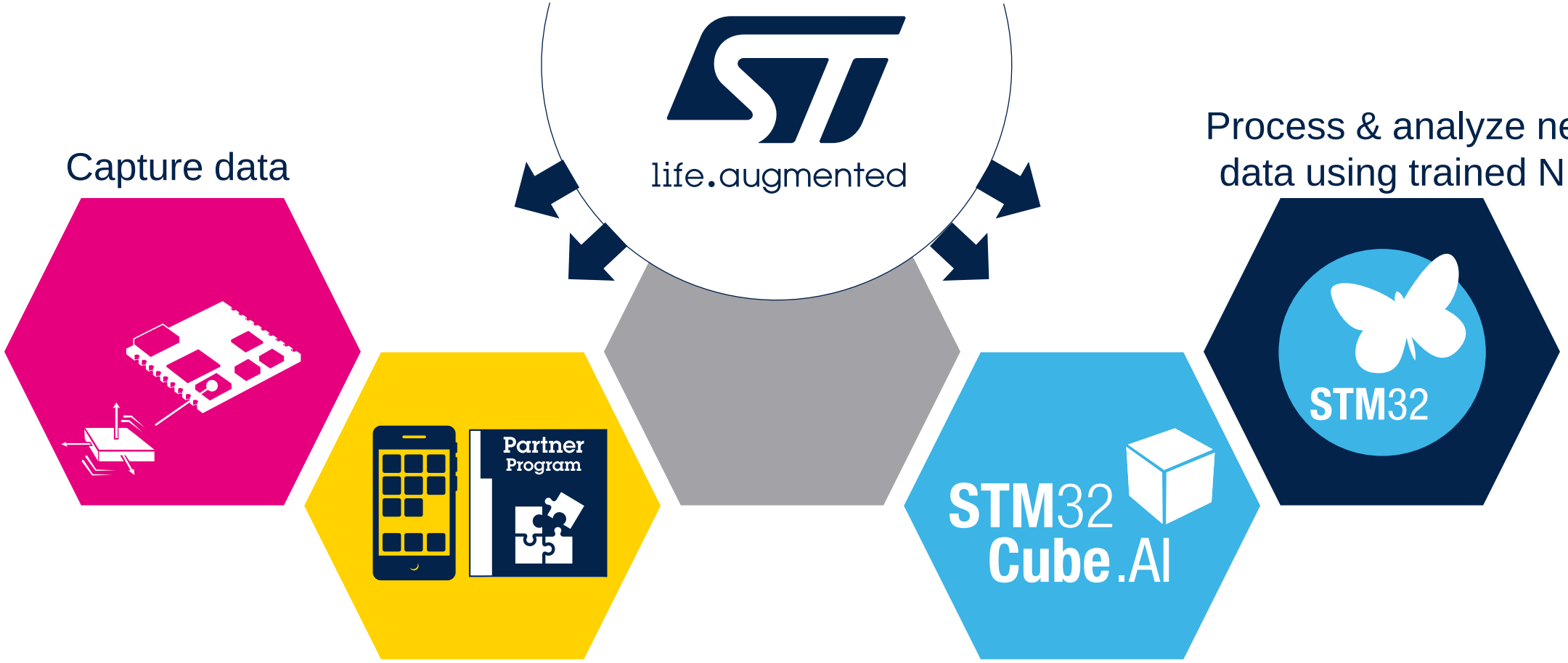
ST toolbox for Neural Networks



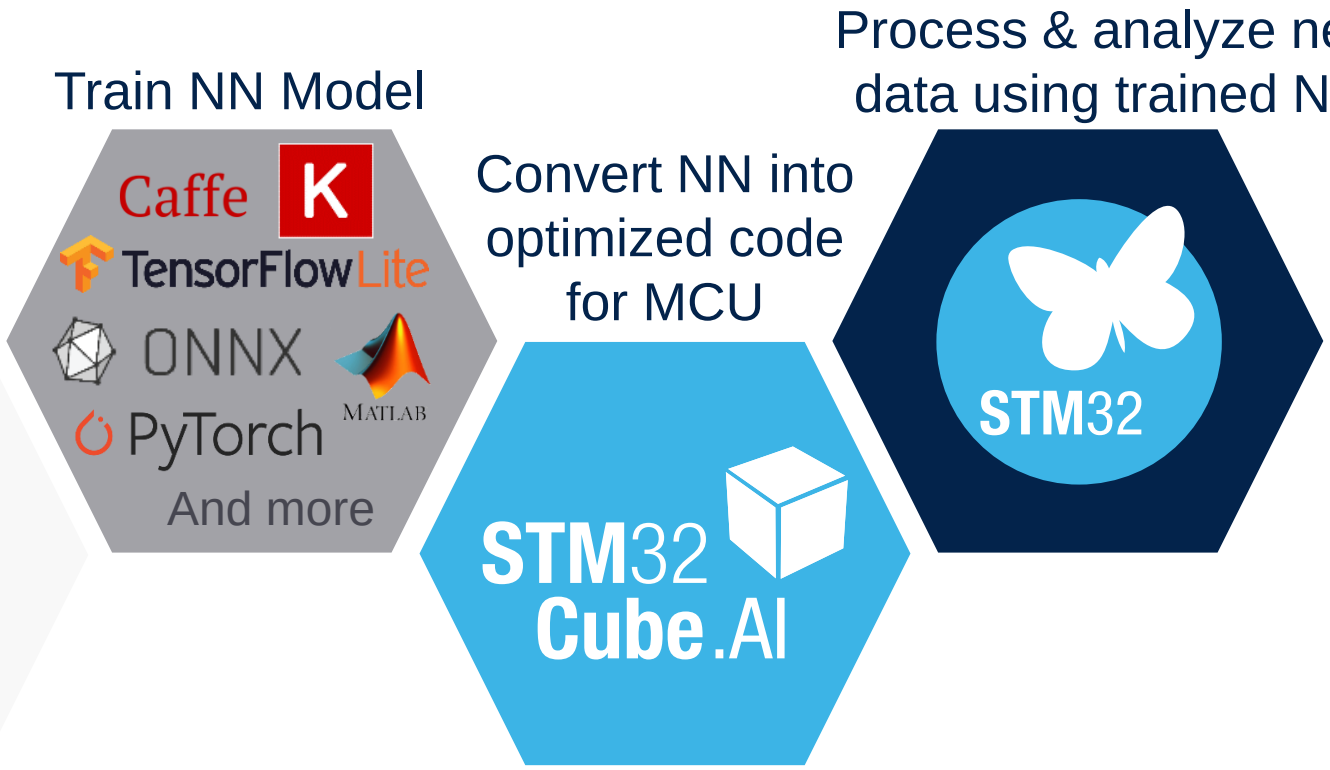
STM32CubeMX extension
AI conversion tool

Input your framework-dependent, pre-trained Neural Network into the **STM**32**Cube**.AI conversion tool

Automatic and fast generation of an STM32-optimized library

STM32**Cube**.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



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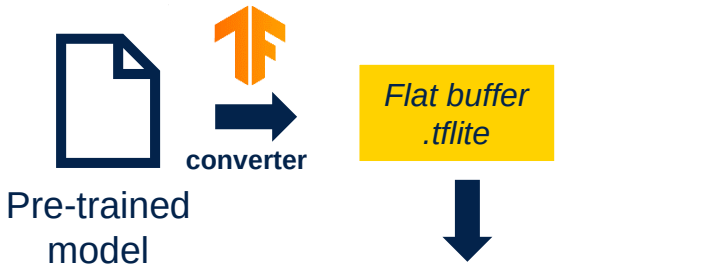
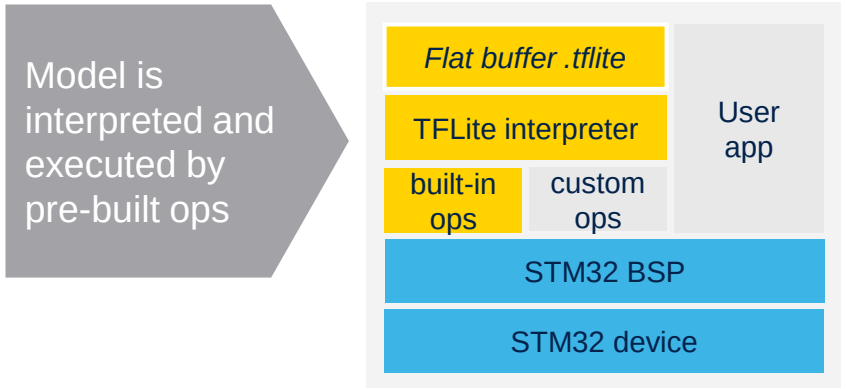
Possible conversion strategies: Network code generation and interpreter

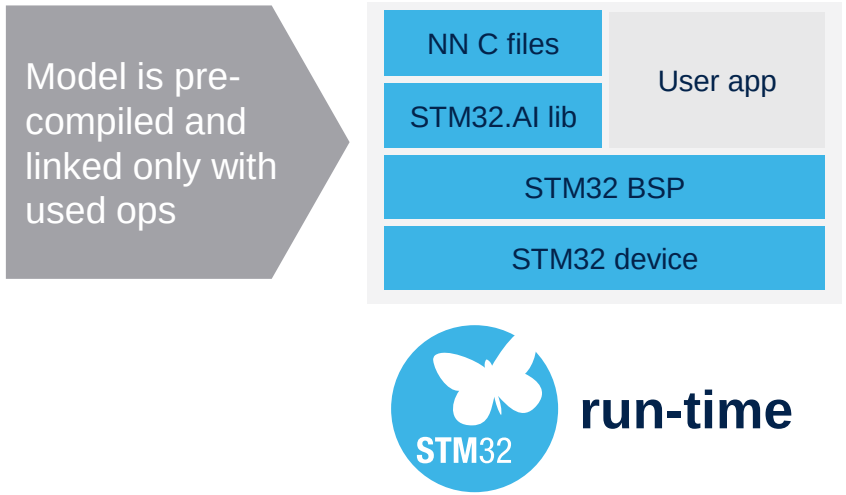
More Flexible: TensorFlow Lite interpreter mode





TensorFlow Lite **run-time on** STM32

More optimized: Optimized C code generated by STM32 Cube.AI



STM32 **run-time**

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Collecting data & architecting a NN topology

Services provided by Partners

Capture data

Clean, label data
Build NN topology

ST tools to support

ST BLE Sensor mobile phone application

Collect and label data from the SensorTile.

ST BLE Sensor

Selected partners

Neural Networks engineering services support.

Data scientists and Neural network architects.

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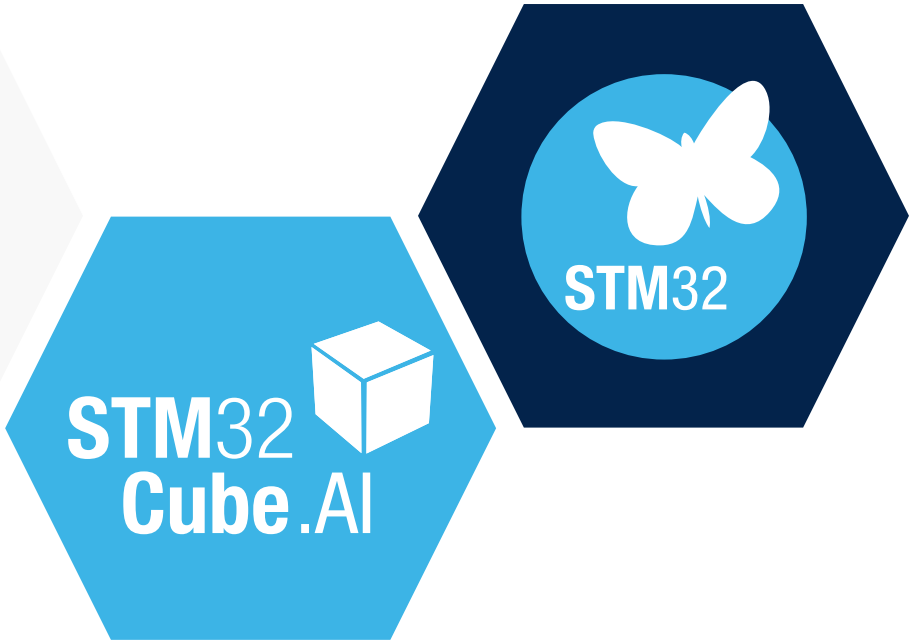
ST toolbox for neural networks more than just a conversion tool

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

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

Process & analyze new data using trained NN

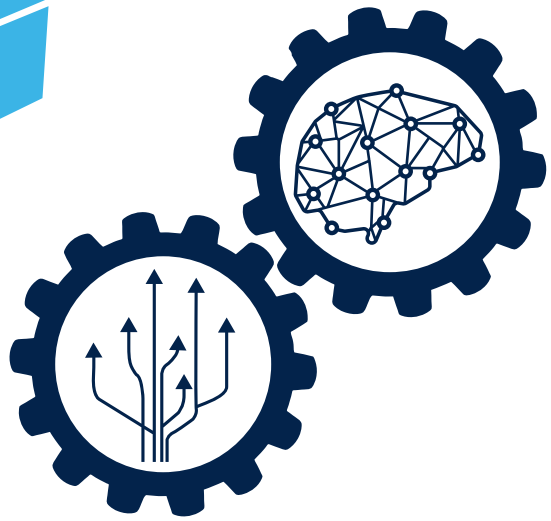


Convert NN into optimized code for MCU

STM32 solutions for AI
More than just the STM32Cube.AI

An extensive toolbox to support easy creation of your AI application

STM32 Cube.AI



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

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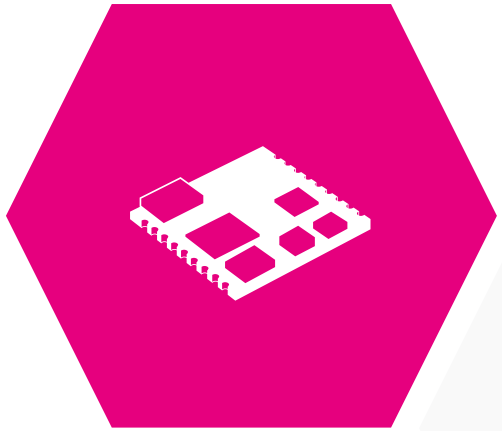
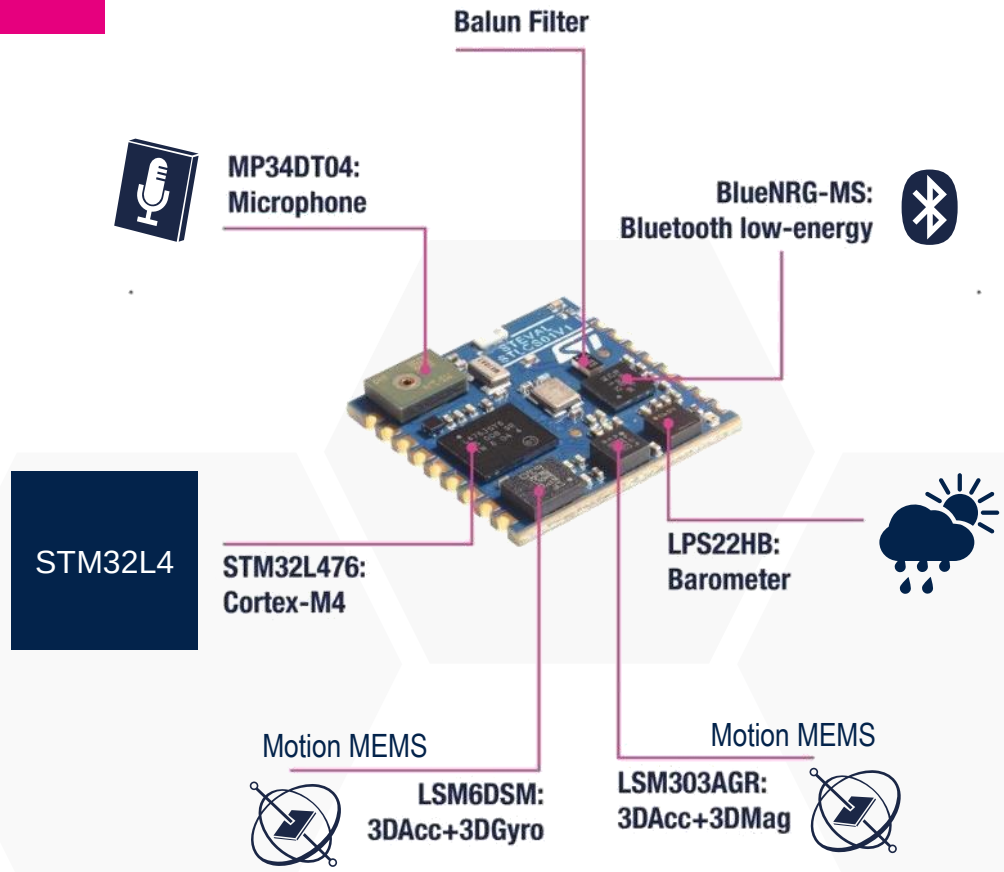
Example form factor hardware to capture and process data

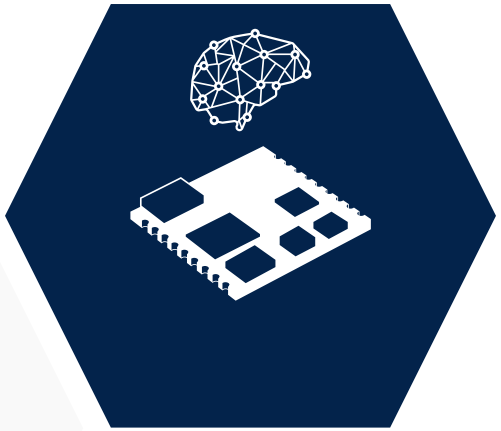
SensorTile

Capture data





Process & analyze new data using trained NN



www.st.com/SensorTile
www.st.com/SensorTile-edu

Fast go to market module to capture data with more accuracy

SensorTile.Box

Capture data

Process & analyze new data using trained NN

Microsoft IoT Services ready

Microsoft Azure

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

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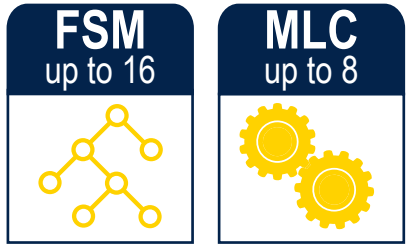
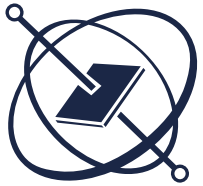
Distributed AI: sensor + STM32
Optimize performance and power consumption

Smart Sensor
with Machine Learning Core





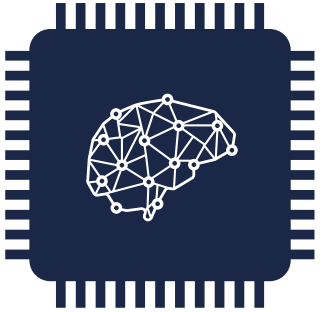
Inertial Sensor
New LSM6DSOX

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

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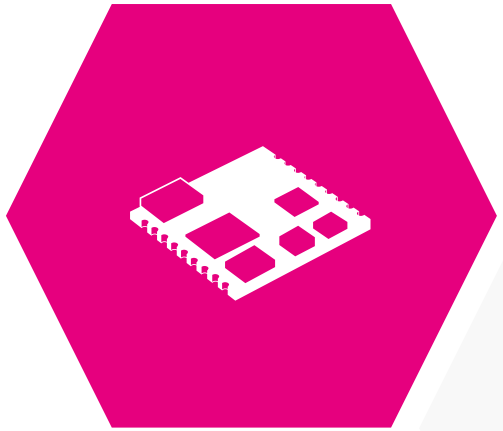
Form factor hardware
AI IoT node for more connectivity

IoTNode

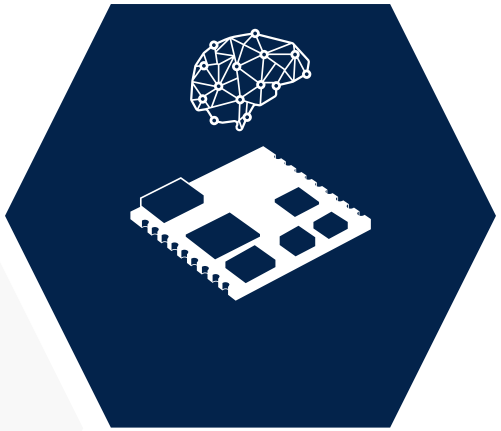
+ Sub-1GHz Dynamic NFC Tag

Wi-Fi

Capture data



Process & analyze new data using trained NN



More debug capabilities

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

https://www.st.com/IoTnode

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OpenMV integration
Fast machine vision prototyping

OpenMV

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

https://github.com/openmv/openmv

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Function Packs

Simple, fast, optimized

STM32 Cube.AI

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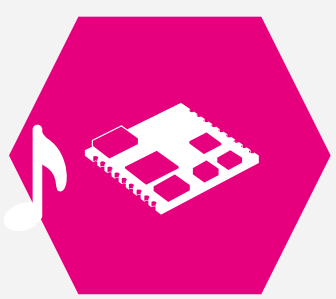
Audio scene classification (ASC)
Audio example in FP-AI-SENSING1 package



3 classes

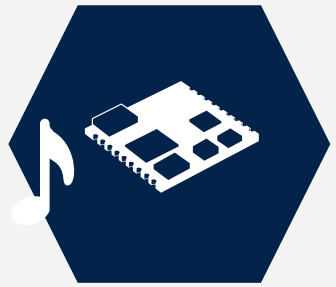
Audio **Data capture**

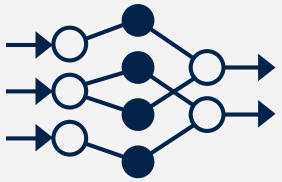
Labelling controlled
by smartphone application

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

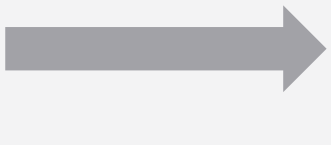
Indoor, Outdoor, In vehicle

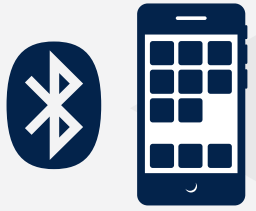
labelling





NN & example
dataset provided





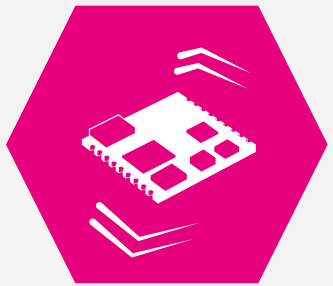
Embedded **audio**
pre-processing

Inferences running
on the microcontroller

Inference result
displayed on mobile app

▶ Demo available

Human activity recognition (HAR)
Motion example in FP-AI-SENSING1 package



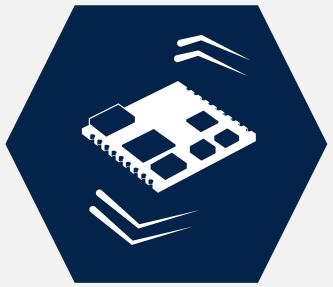
5 classes example

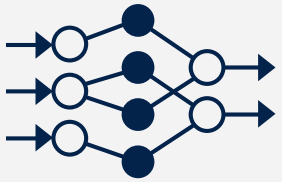
Motion **Data Capture**

Labelling controlled
by smartphone application

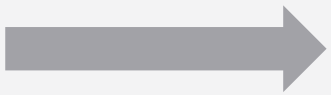
Data stored on the device
SD card for future **learning**

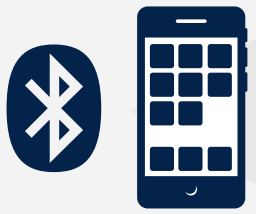
Stationary, walking, running,
biking, driving **labelling**





NN & example
dataset provided





Embedded **motion**
pre-processing

Inferences running
on the microcontroller

Inference result
displayed on mobile app

► Demo available

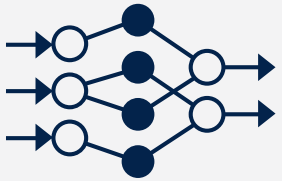
Image classification
Vision example in FP-AI-VISION1 package

Enjoy the food classification demo

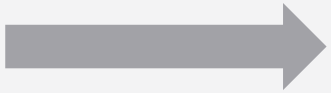
- Default demo based on 18 classes (224x224 RGB pictures)
- Several camera image output size possible

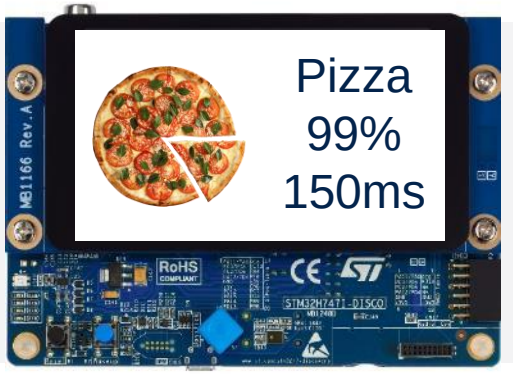
Full end-to-end optimized software example

- 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

▶ Demo available

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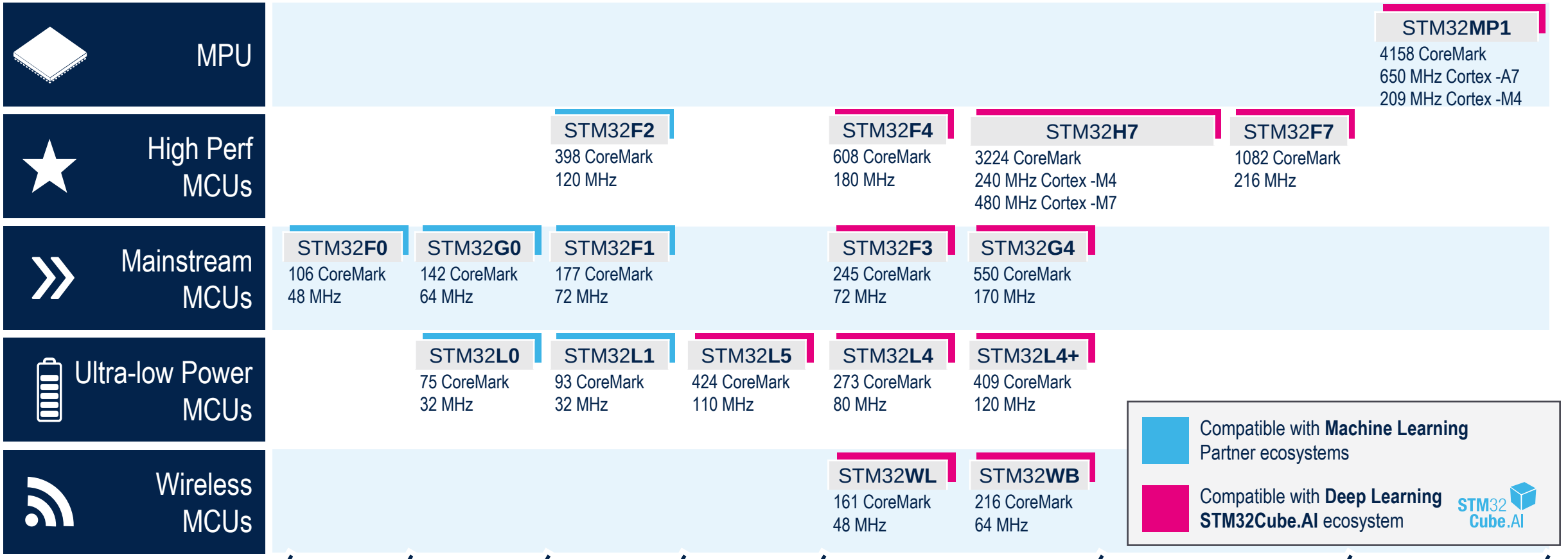
Making AI Accessible Now

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



More than 40,000 customers

Over 4 Billion STM32 shipped since 2007

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AI solutions for STM32MP1

Running AI on ST Microprocessors

STM32 Cube.AI

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STM32MP1 microprocessor
Augmented intelligence

STM32**MP1** =

Cortex-M4
Realtime OS
STM32CubeMX

+

Dual Cortex-A7
OpenSTLinux Distribution
STM32CubeMx

STM32 Cube.AI

X-LINUX-AI-CV
support for
TensorFlow Lite
&
OpenCV

- 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

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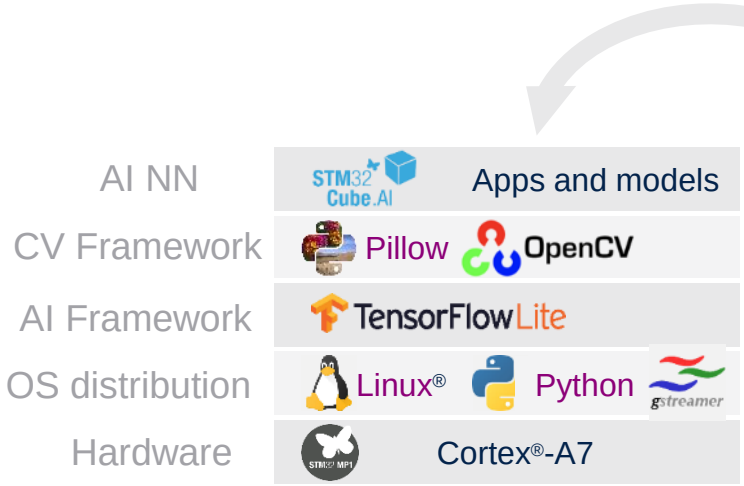
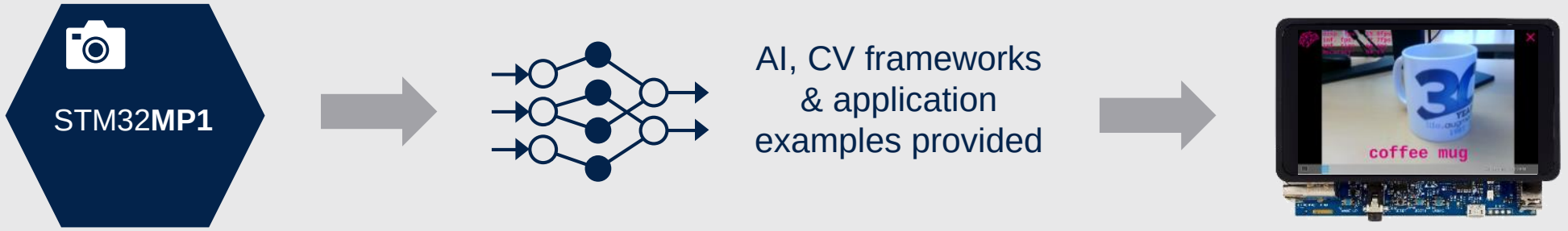
X-LINUX-AI-CV Package for STM32MP1 Computer Vision Application



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



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

▶ 2x demos available

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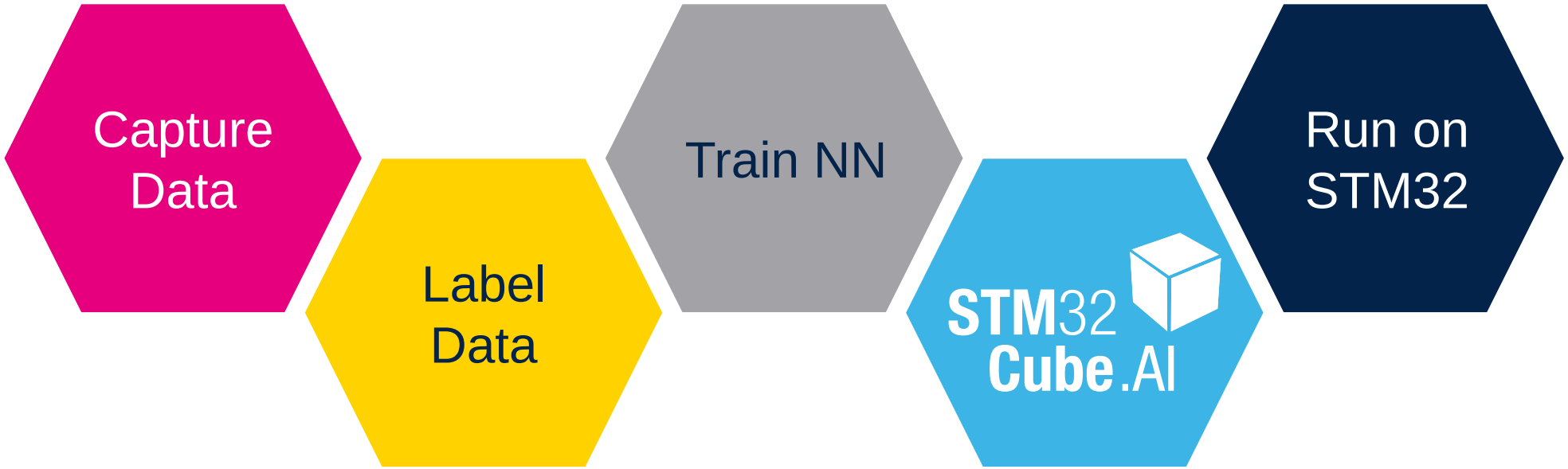
For more information

www.st.com/STM32CubeAI



Releasing your creativity

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community.st.com

www.st.com/STM32CubeAI

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Thank you

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