



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



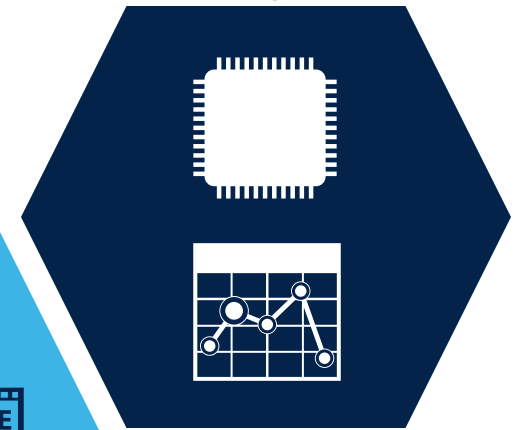
3

4



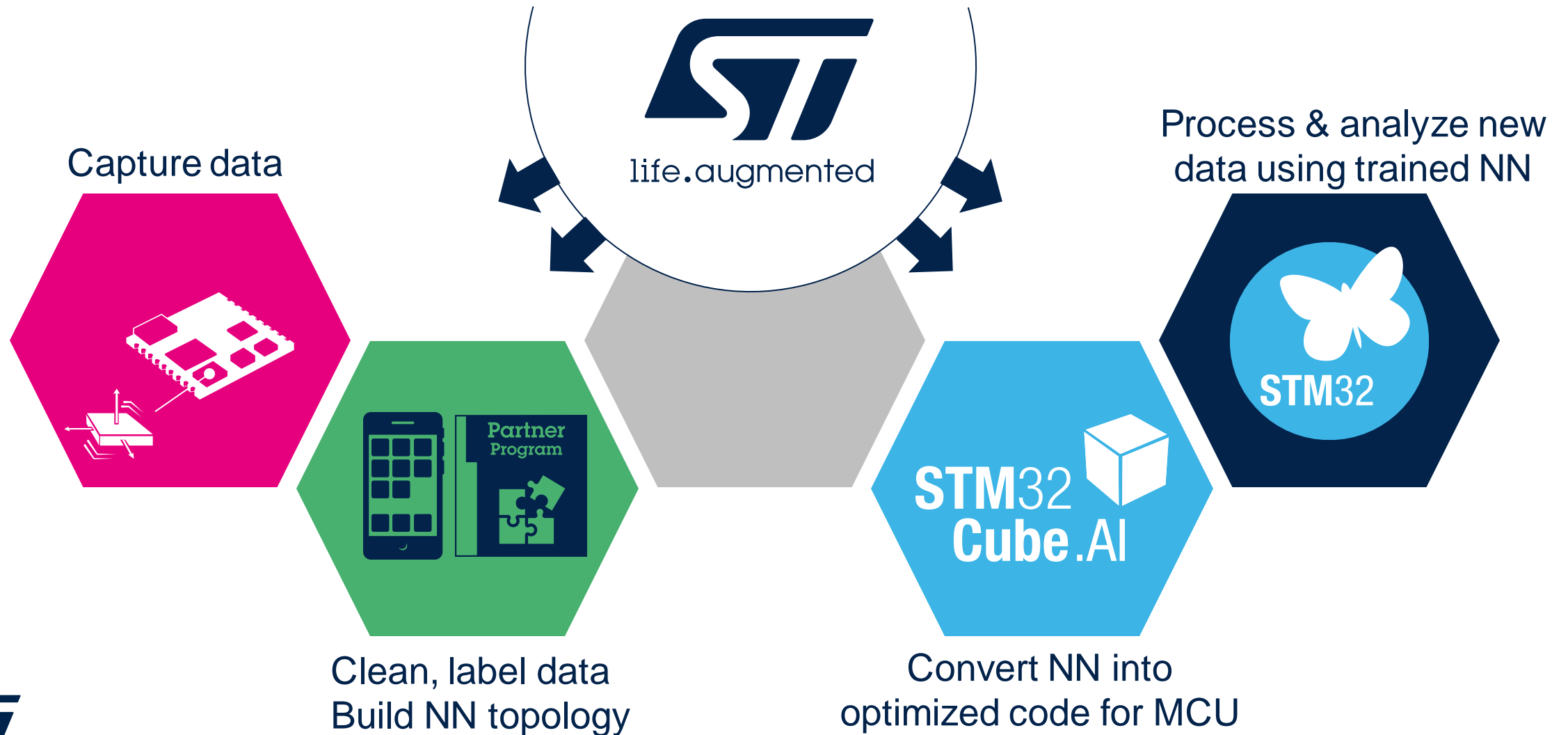
Convert NN into
optimized code for MCU

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

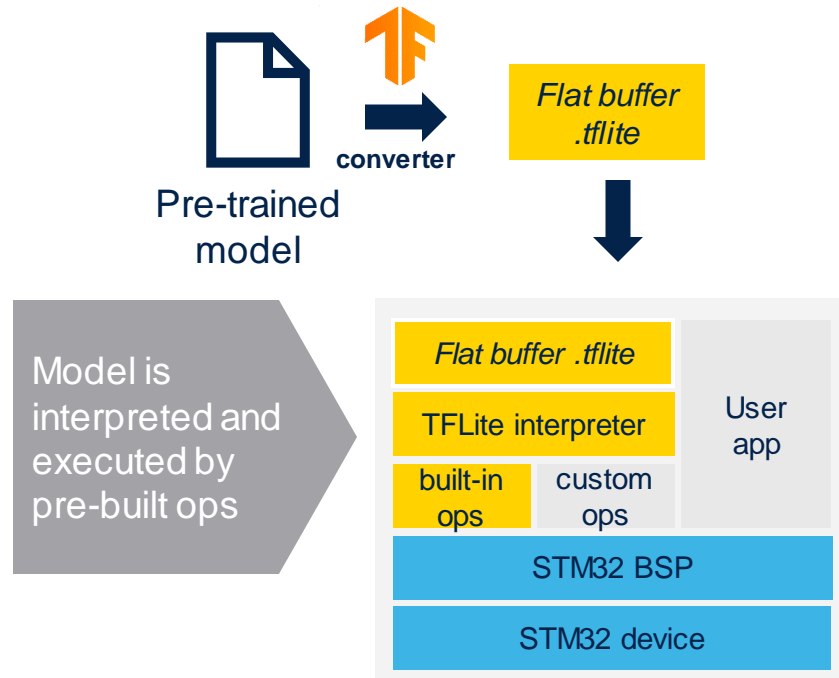


Process & analyze new
data using trained NN



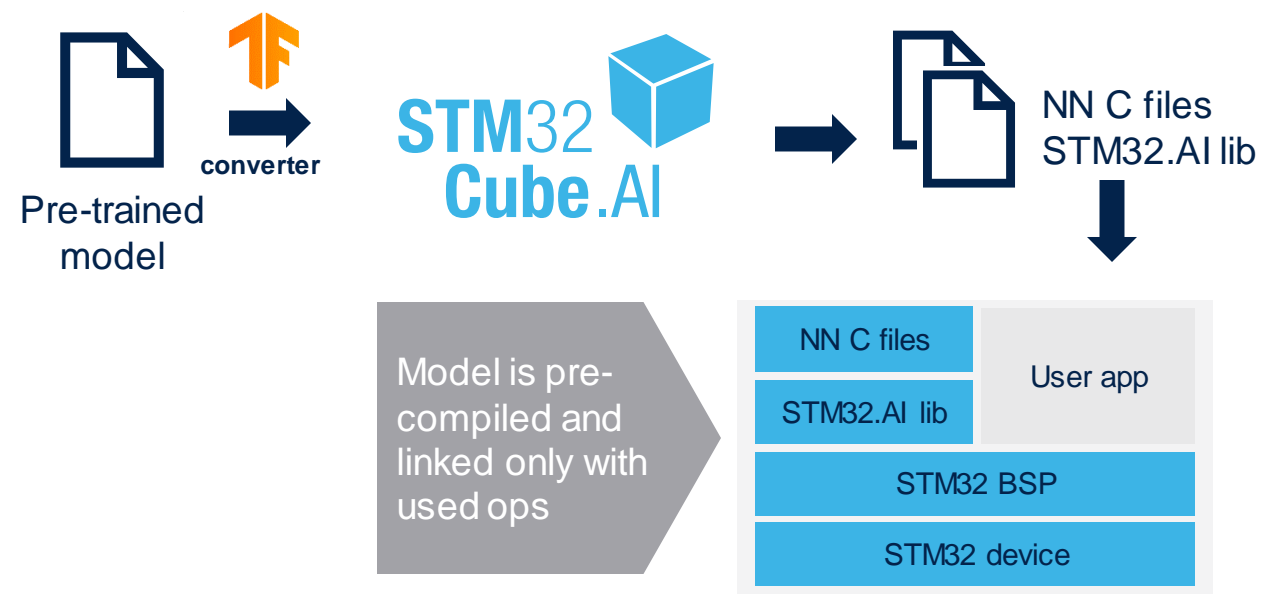
Possible conversion strategies: Network code generation and interpreter

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 mobile phone application
Collect and label data from the SensorTile.



ST BLE
Sensor

**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

Process & analyze new
data using trained NN



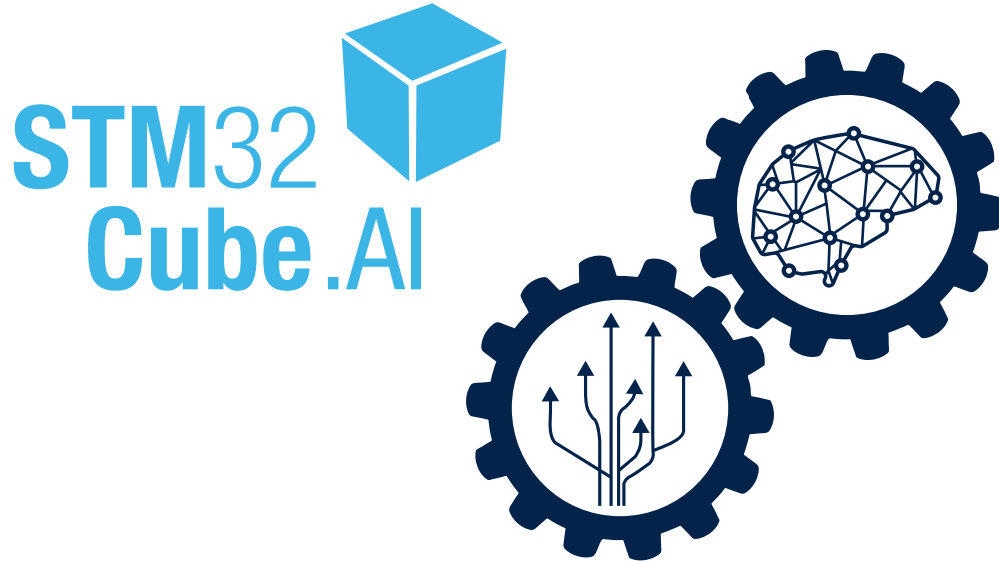
Convert NN into
optimized code for MCU



STM32 solutions for AI

More than just the STM32Cube.AI

An extensive toolbox to support easy creation of your AI application



- 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

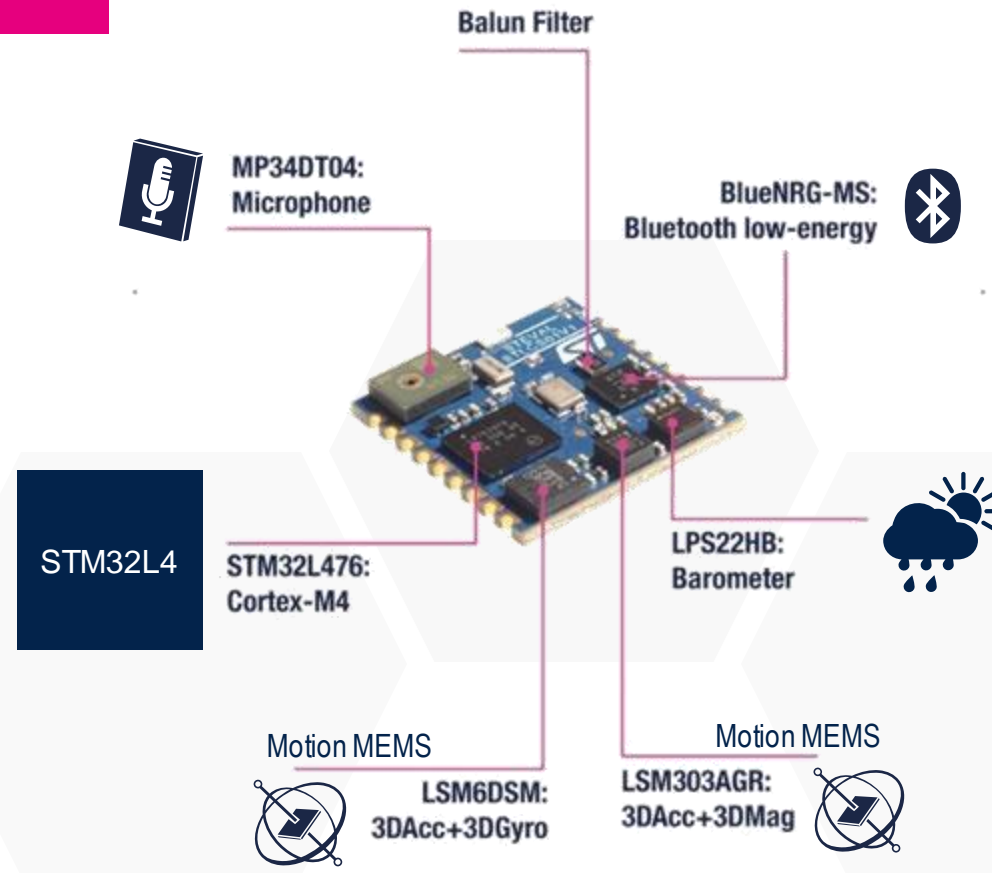
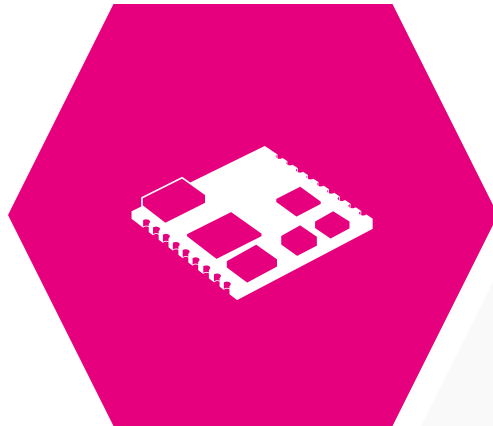
STM32 AI Partner Program
with dedicated Partners providing
Machine or Deep Learning engineering services



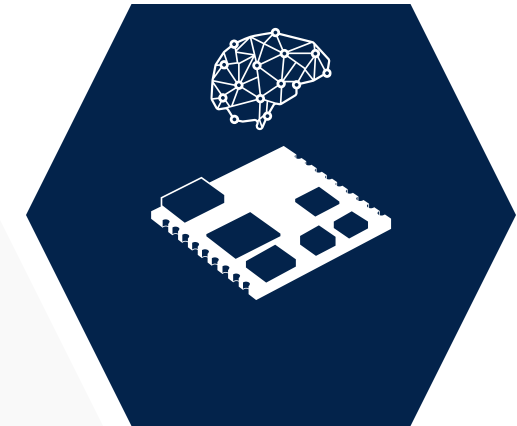
Example form factor hardware to capture and process data

SensorTile

Capture data



Process & analyze new data using trained NN

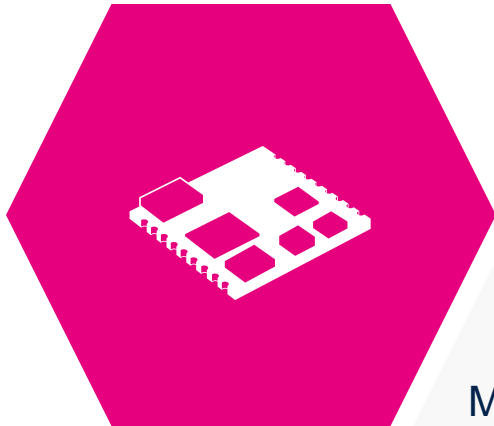




Fast go to market module to capture data with more accuracy

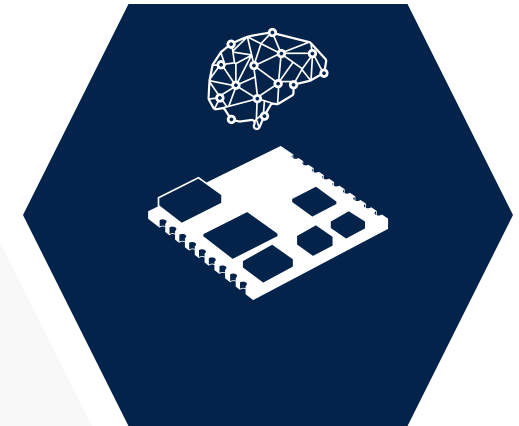
SensorTile.Box

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

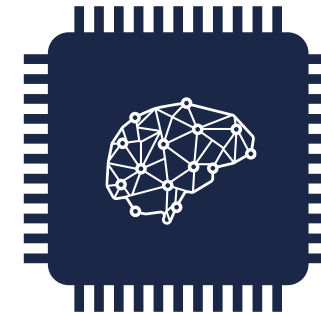


Raw Data

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

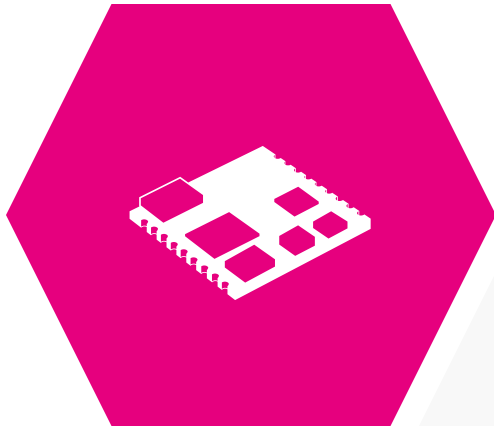
- More advanced and complex NNs
- Decisions on multiple sensors
- NN input can be sensor data and/or sensor Machine Learning decisions
- Multiple Neural Networks support
- Actuation & communication



Form factor hardware AI IoT node for more connectivity

IoTNode

Capture data



+

Sub
1GHz

Sub-1GHz

NFC

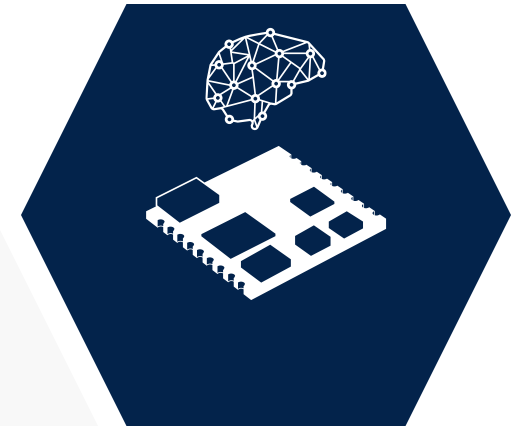
Dynamic NFC Tag

Wi-Fi

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

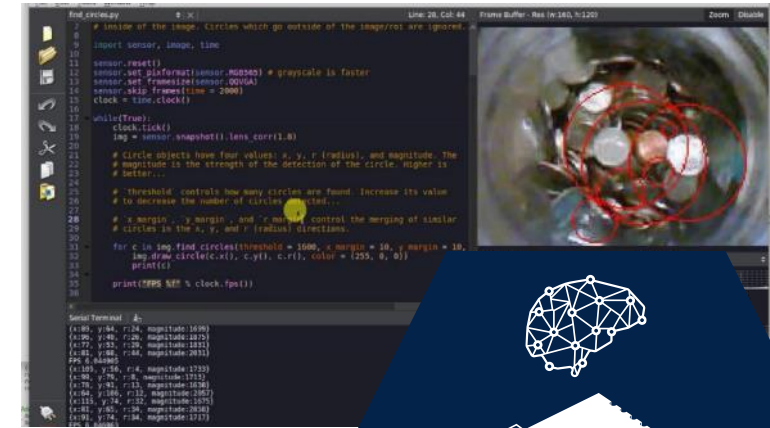


OpenMV CAM
Running MicroPython over STM32

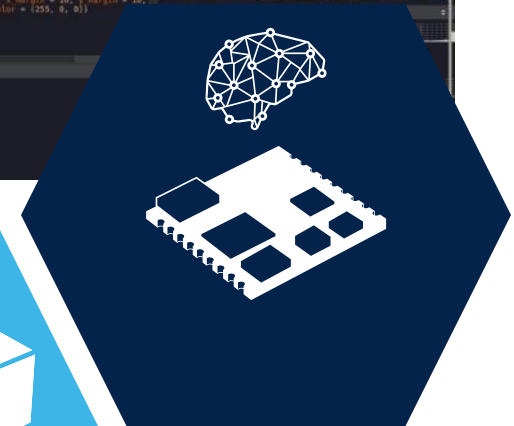
Configure Machine Vision in
real-time over USB in Python



Run and validate optimized
Neural Network



STM32
Cube.AI



Function Packs

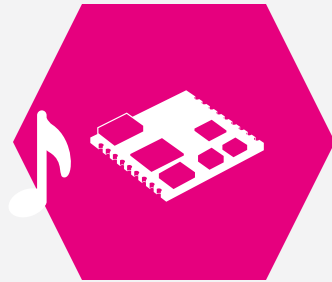
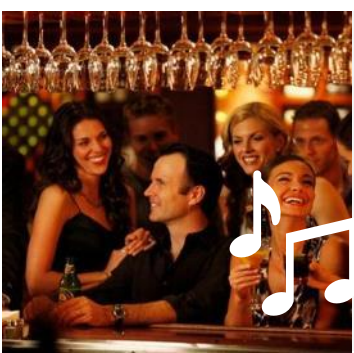
Simple, fast, optimized

STM32 
Cube.AI



Audio scene classification (ASC)

Audio example in FP-AI-SENSING1 package



Audio Data capture



Labelling controlled
by smartphone application

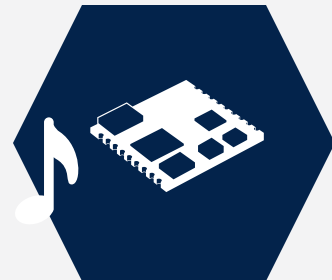


Data stored on the device
SD card for future learning

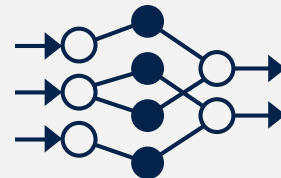


3 classes

Indoor, Outdoor, In vehicle
labelling



Embedded audio
pre-processing



NN & example
dataset provided

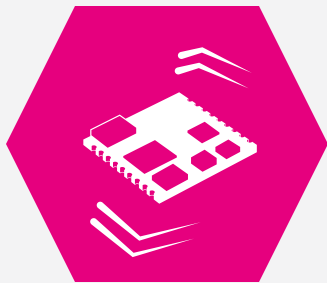


Inference result
displayed on mobile app

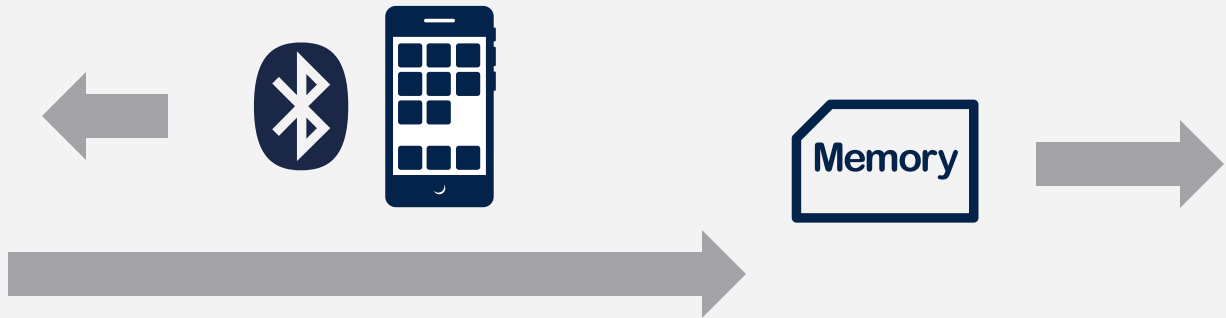


Human activity recognition (HAR)

Motion example in FP-AI-SENSING1 package



Motion Data Capture



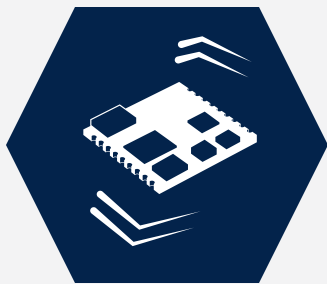
Labelling controlled by smartphone application

Data stored on the device SD card for future learning



5 classes example

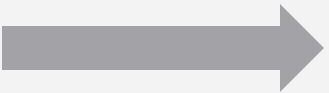
Stationary, walking, running, biking, driving labelling



Embedded motion pre-processing



Inferences running on the microcontroller



Inference result displayed on mobile app



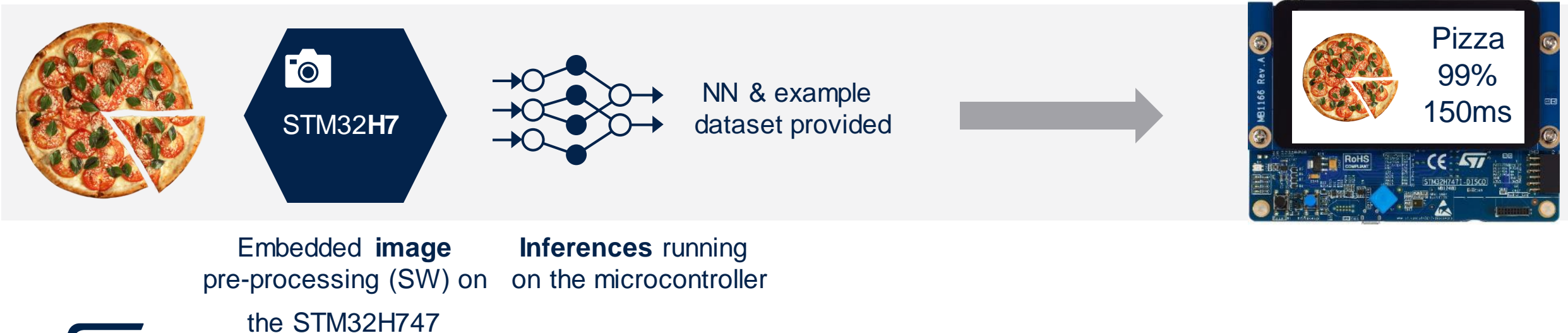
Image classification Vision example in FP-AI-VISION1 package

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

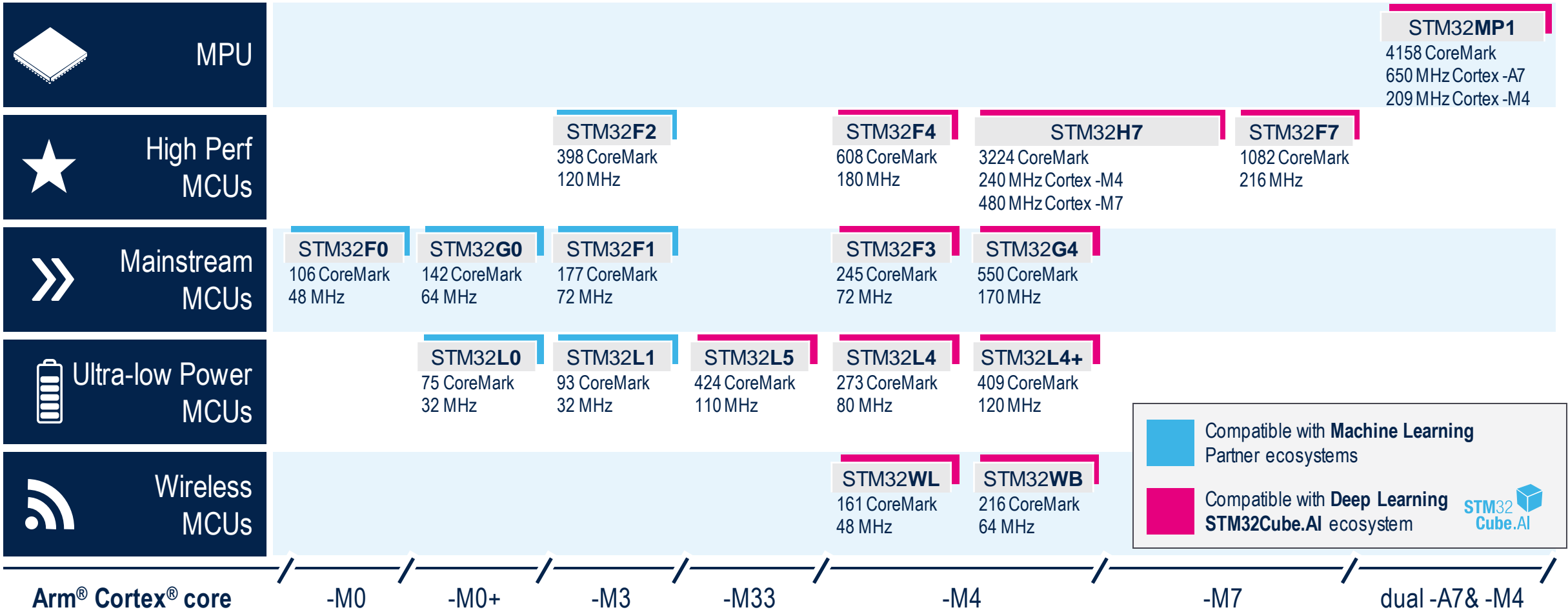
- from camera acquisition to image pre-processing before feeding the NN
- Multiple memory mapping possibilities to optimize and test impact on performances
- Retrain this NN with your own dataset
- Quantize your trained network to optimized inference time and memory usage





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

AI solutions for STM32MP1

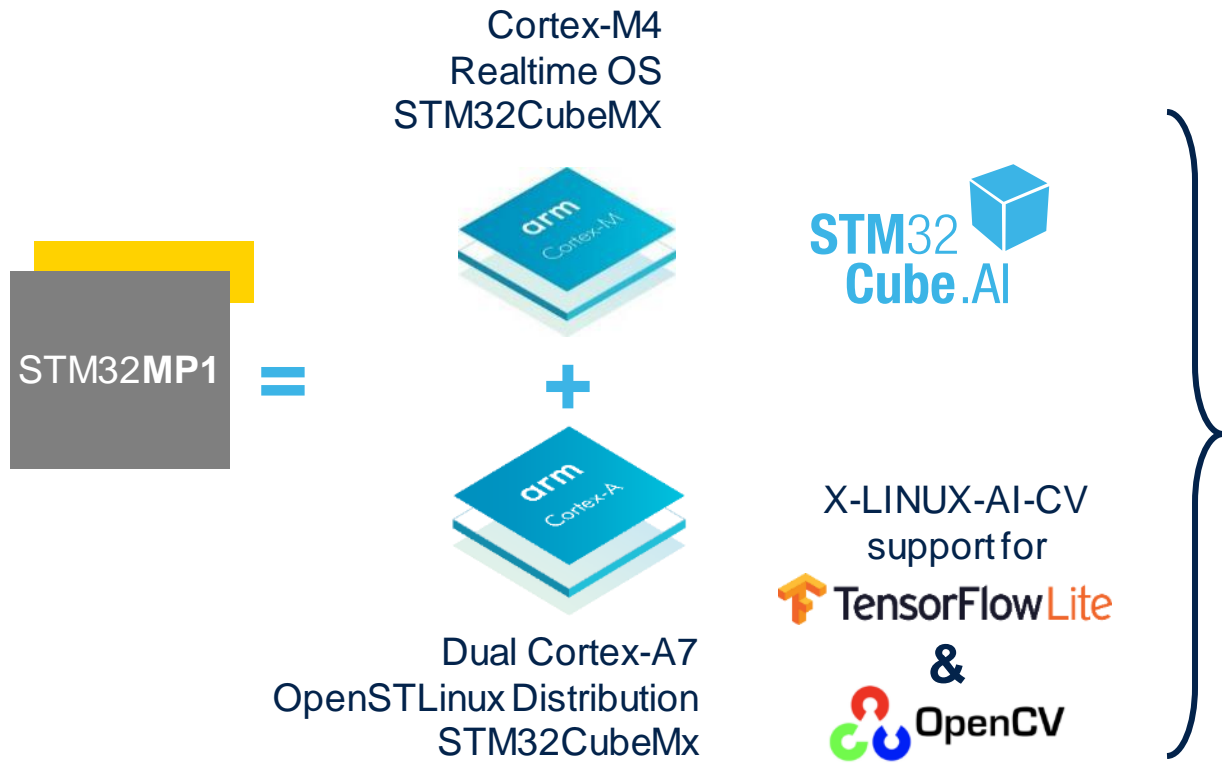
Running AI on ST
Microprocessors

STM32 
Cube.AI



STM32MP1 microprocessor

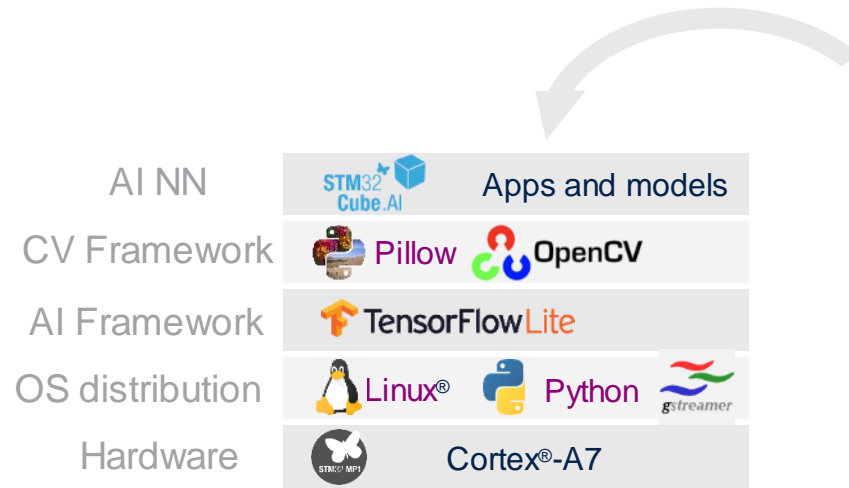
Augmented intelligence



- 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



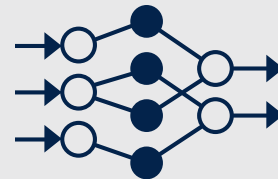
Application examples in C/C++ and Python

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

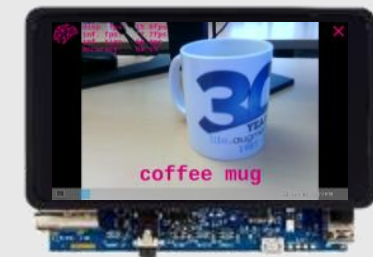
Includes code for camera acquisition and image pre-processing



USB camera or
built-in camera
module



AI, CV frameworks
& application
examples provided



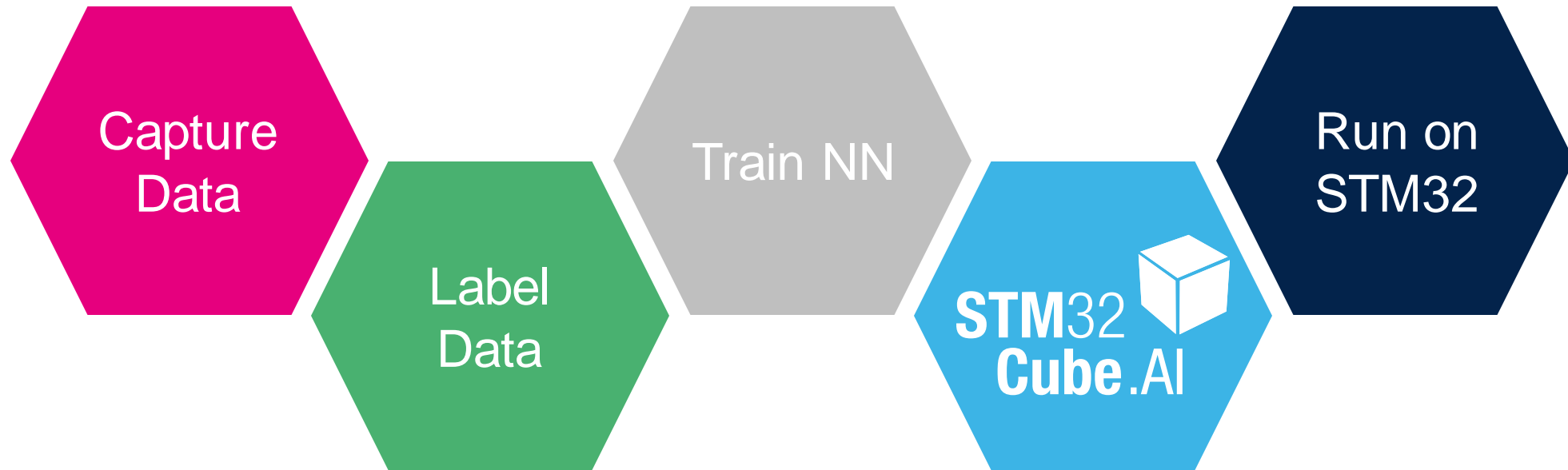
Inferences running on the
microprocessor in 80ms
for image classification

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

For more information



www.st.com/STM32CubeAI



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