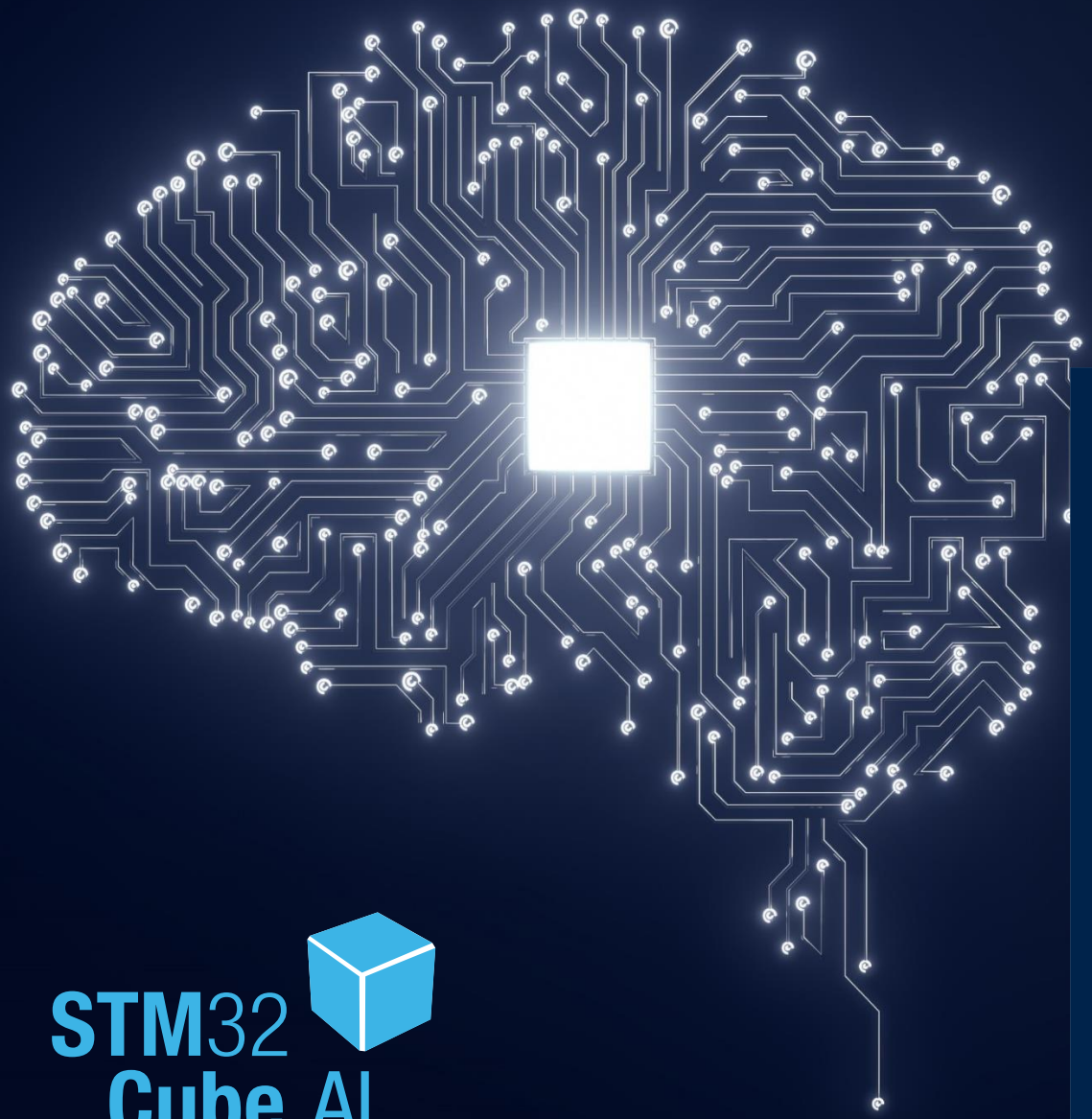


life.augmented

STM32 Artificial Intelligence Solutions

STM32 Cube.AI

Raphael Apfeldorfer - Feb 2021

MDG/MCD/AI Solutions

STM32

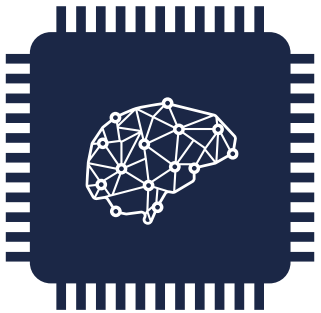
Artificial Intelligence at the Edge

Moving part of intelligence closer to the data acquisition

Better user experience

Realtime, no latency

Reliable



Add new functions and services with **Embedded AI**

Optimized Cloud usage

Privacy by design (GDPR compliant)

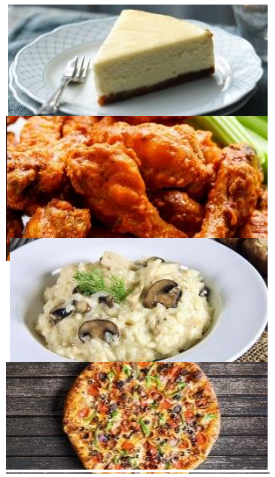
Sustainable on energy

life.augmented

Contact us at edge.ai@st.com

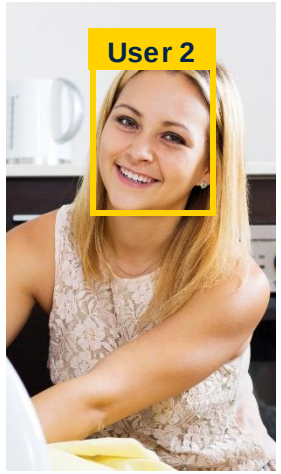
Computer Vision for STM32

Give vision to your STM32 product for new features and add-on services



Food classification

Person presence detection



Face recognition

Multiple object detection

FP-AI-VISION1 v1.0	FP-AI-VISION1 v2.0	FP-AI-FACEREC v1.0	Q2 2021*

*available for alpha customers

Keras TensorFlowLite ONNX

PyTorch And more

STM32 Cube.AI ⟷ STM32 CubeMX

Optimized NN files

STM32.AI lib

Customer application

STM32.Vision lib

STM32 run-time

life.augmented

Condition monitoring for STM32

Monitor STM32 equipment health for improved uptime and lower maintenance cost

Vibration monitoring for In-field retrofit of existing systems

Condition monitoring with current for build-in systems

FP-AI-NANOEDG1 v1.0	Q1 2021*

*available for alpha customers

Get started using dedicated And industrial boards

STM32 CubeExpansion

STM32 Cube.AI ⟷ STM32 CubeMX

Optimized NN files	Customer application
STM32.AI lib	ML models

STM32 run-time

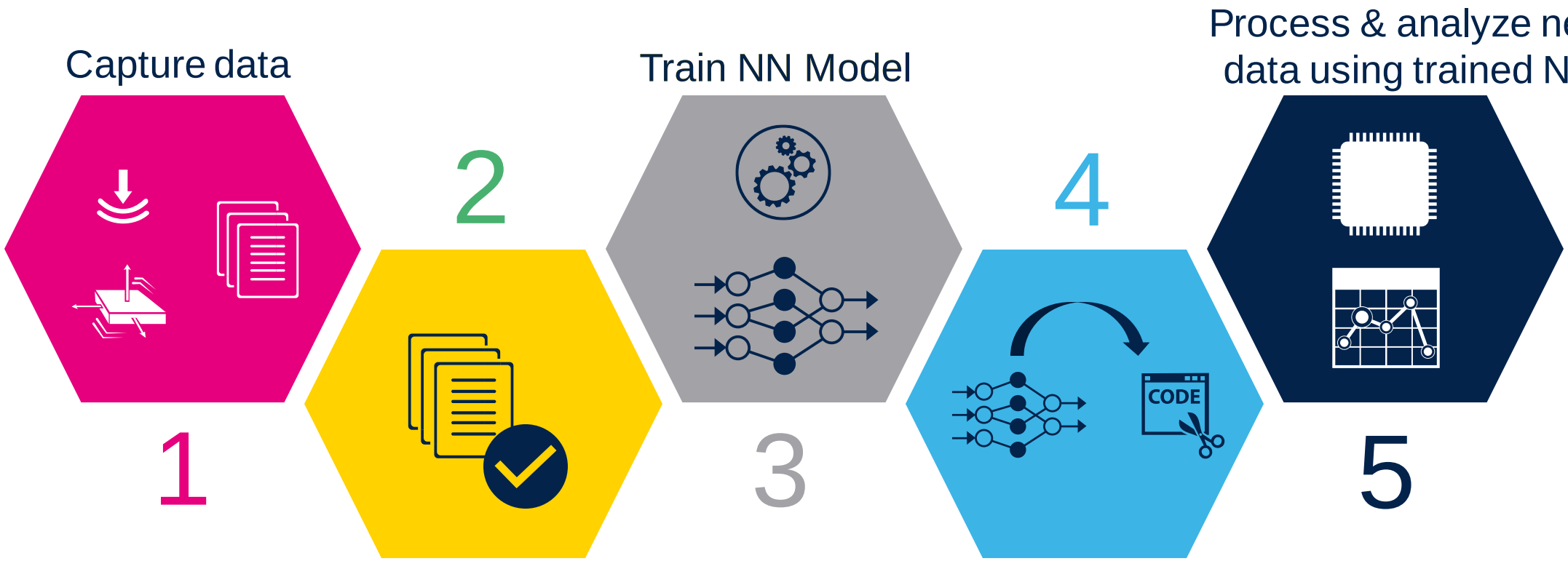
life.augmented

AI tools for STM32

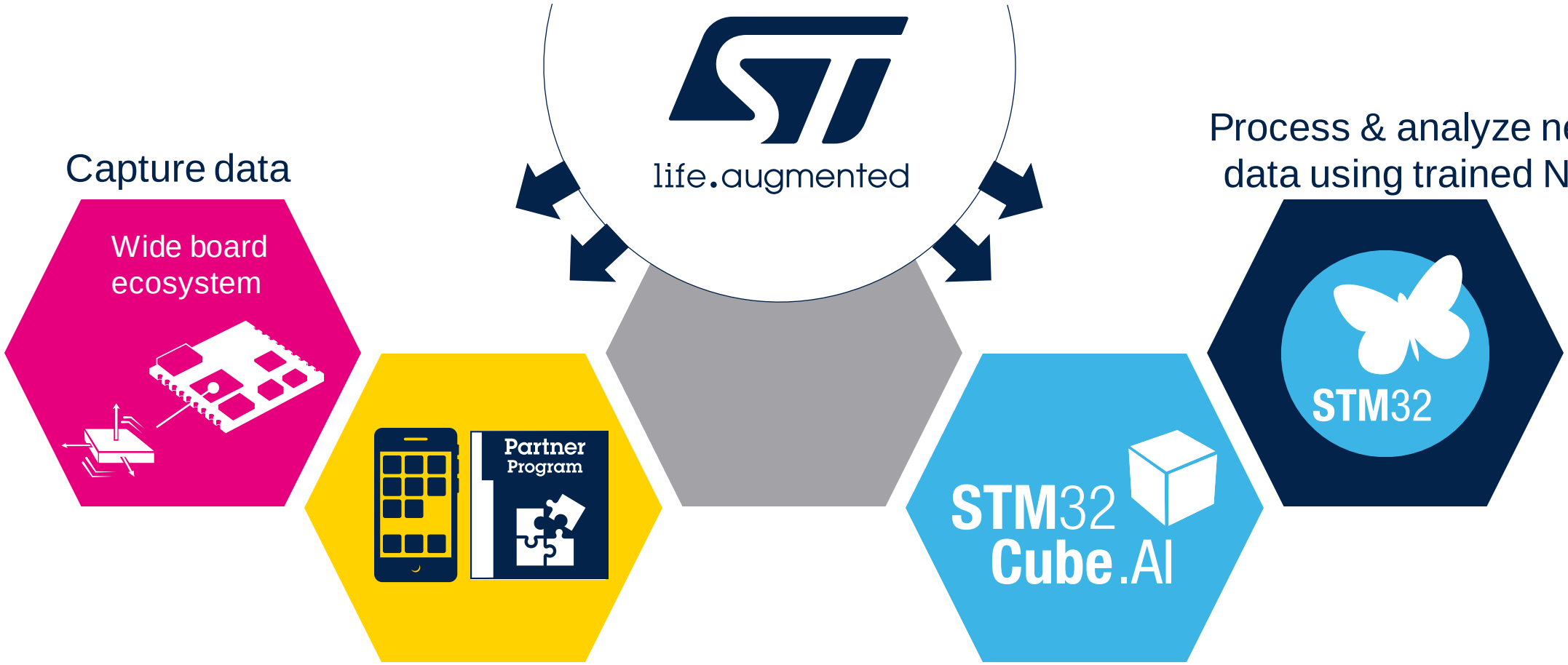
life.augmented

The key steps behind Neural Networks

Neural Network (NN) Model Creation | Operating Mode

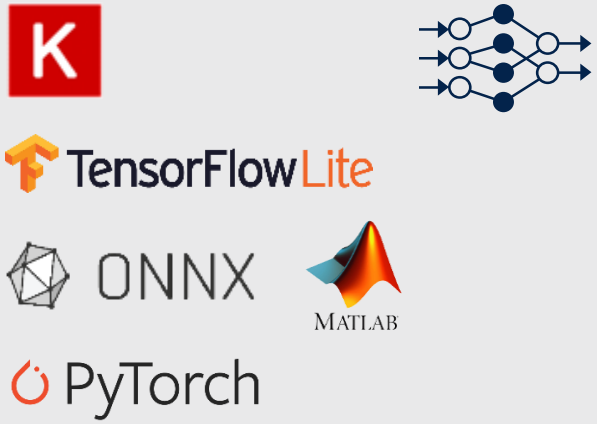


ST toolbox for Neural Networks



Easily implement Neural Networks on STM32

Train Neural Network using any major AI frameworks



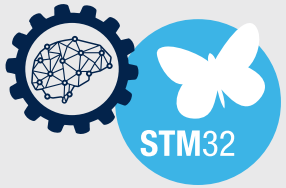
and more…

Convert NN into optimized code

STM32 Cube.AI

- Select most appropriate MCU
- Review computation and memory consumption per layer

Run on optimized runtime



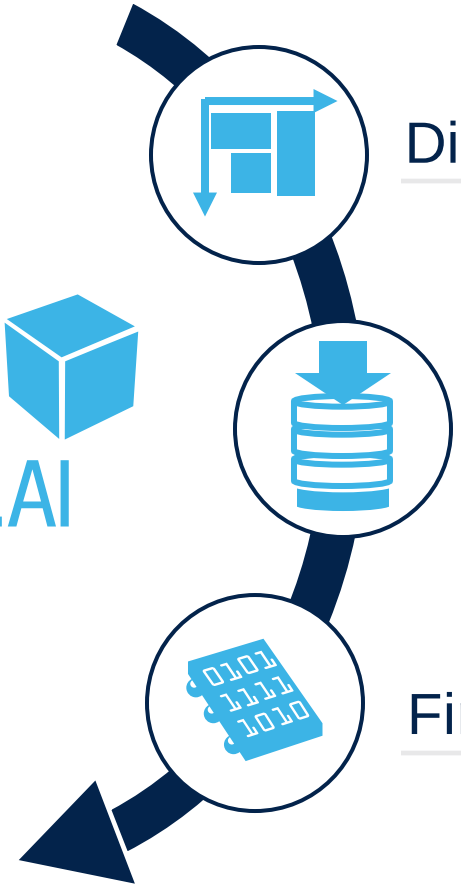
run-time

- Validate code directly on target
- Get accuracy and inference time
- Optimize memory usage

life.augmented

STM32Cube.AI main features

STM32Cube.AI is available both as graphical and command line interface



Dimension

- Quickly assess model footprint requirements
- Select and configure MCU in STM32CubeMX
- Review model layers in STM32Cube.AI

Optimize

- Generate C-code for pre-trained model
- Support quantized models to reduce RAM, flash and latency with minimal loss of accuracy
- Use light run-time libraries
- Optimize for performance

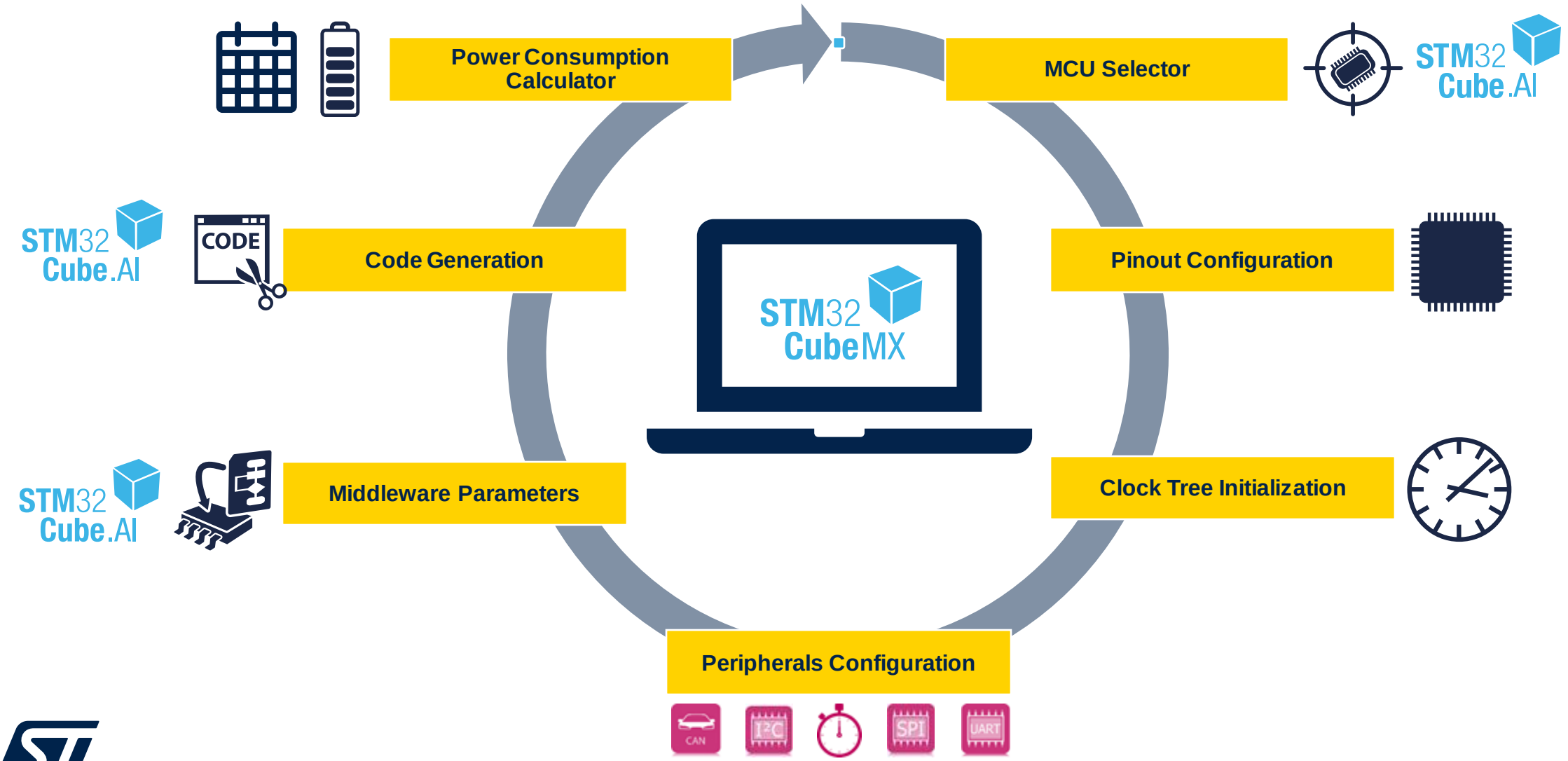
Fine Tune

- Optimize memory allocation
- Fine control of weight mapping
- Split between internal and external memory
- Update model without full FW update

And quickly iterate thanks to on-target validation

life.augmented

STM32Cube.AI, an STM32CubeMX expansion



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

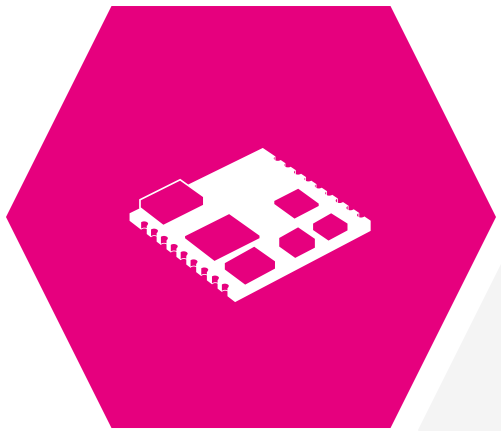
Neural Networks engineering services support.

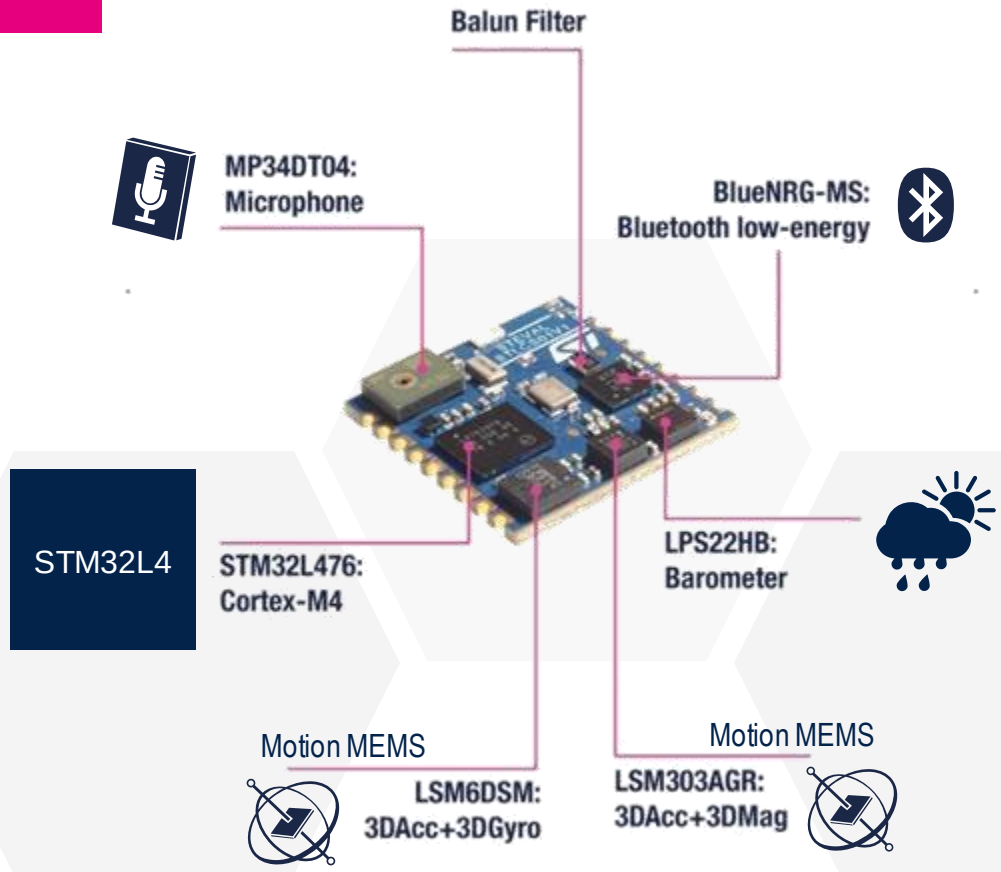
Data scientists and Neural network architects.

Example form factor hardware to capture and process data

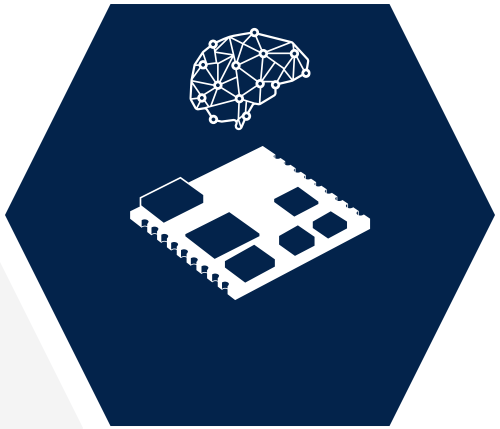
SensorTile

Capture Data





Inference on **STM32**L476



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

Fast go to market module to capture data with more accuracy

SensorTile.Box

Capture Data

Inference on **STM32**L4R9

Microsoft IoT services ready

Microsoft Azure

More advanced, high accuracy and low power sensors

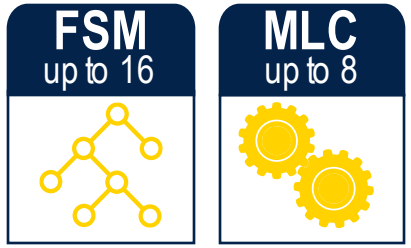
- First Inertial module with Machine Learning capabilities.
- Motion (accelerometer and gyroscope, magnetometer) and slow motion (inclinometer)
- Altitude (pressure), environment (pressure, temperature, humidity, compass) and sound (sound and ultrasound analog microphone)
- Microsoft IoT services ready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

www.st.com/SensorTileBox

life.augmented

Distributed AI: sensor + STM32
Optimize performance and power consumption

Smart Sensor
with Machine Learning Core



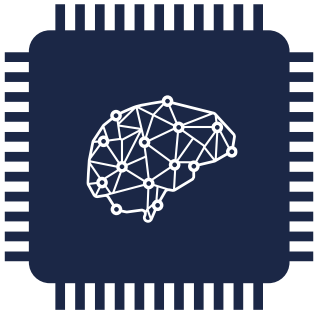
Inertial Sensor
New LSM6DSOX

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

life.augmented

Form factor hardware
AI IoT node for more connectivity

B-L475E-IOT01A

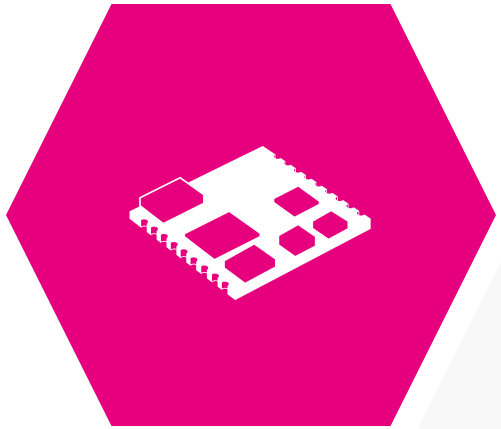
\+

Sub 1GHz Sub-1GHz

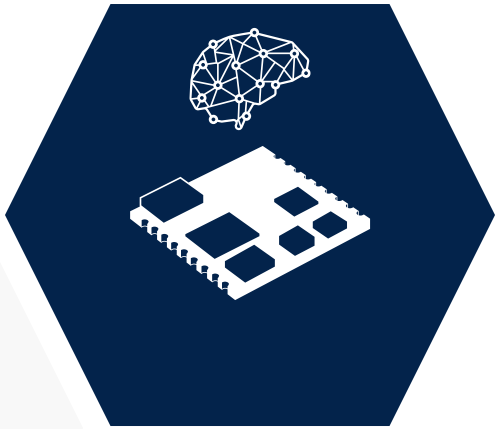
NFC Dynamic NFC Tag

Wi-Fi Wi-Fi

Capture Data



Inference on **STM32**L4



More debug capabilities

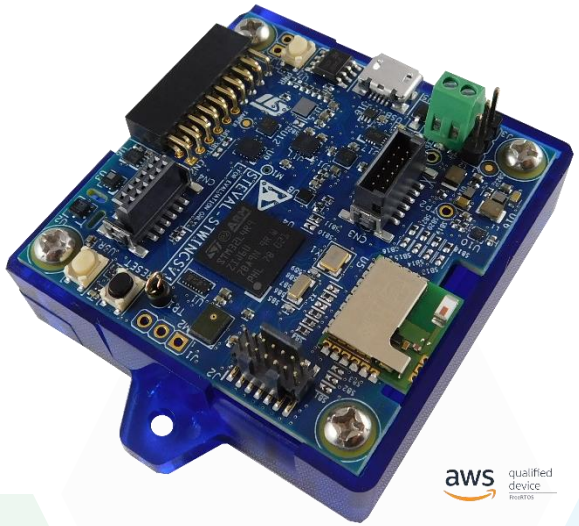
- Integrated ST-Link/V2.1
- PMOD extension connector
- Arduino Uno extension connectors

www.st.com/IoTnode

life.augmented

Wireless Industrial node to capture data at industrial grade

STWIN



Capture Data

Inference on **STM32**L4R9

Industrial-grade sensors

- Industrial scale 9-DoF motion sensors including accelerometer, gyrometer and an ultra wide-bandwidth 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
- BLE5.0 connectivity and WiFi expansion board
- USART

www.st.com/stwin

life.augmented

STM32H7 discovery boards with camera

STM32H747I-DISCO
with B-CAMS-OMV

Capture Data

Inference on STM32H747

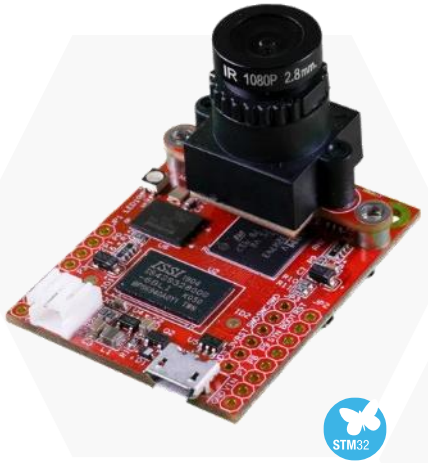
Computer Vision on microcontroller

- STM32H747 high-performance and DSP with DP-FPU, Arm Cortex-M7 at 480 MHz + Cortex-M4 MCU with 2MB internal Flash, 1MB internal RAM, Chrom-ART Accelerator
- External memory 2x64MB Quad-SPI NOR Flash and 32MB SDRAM
- 4” capacitive touch LCD display module with MIPI® DSI interface
- Camera module adapter board and camera module based on OV5640 5MPx 8b color rolling shutter
- ST-MEMS digital microphones
- Ethernet RJ45 and Wi-Fi / cellular expansion boards

life.augmented

OpenMV integration
Fast machine vision prototyping

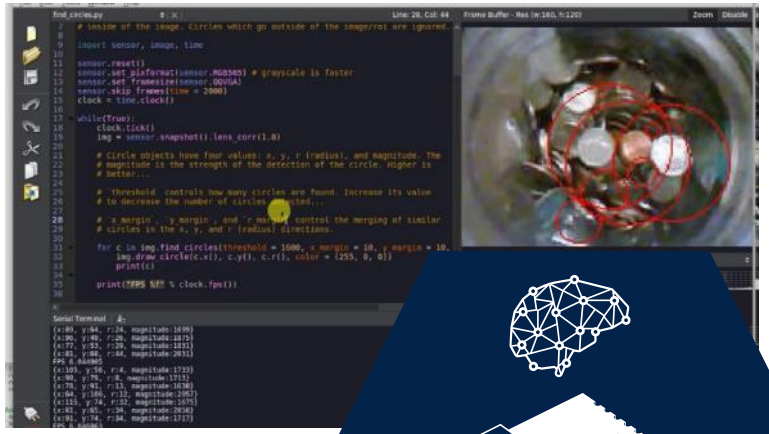
OpenMV



OpenMV CAM
Running MicroPython over STM32

Configure Machine Vision in real-time over USB in Python

Run and validate optimized Neural Network



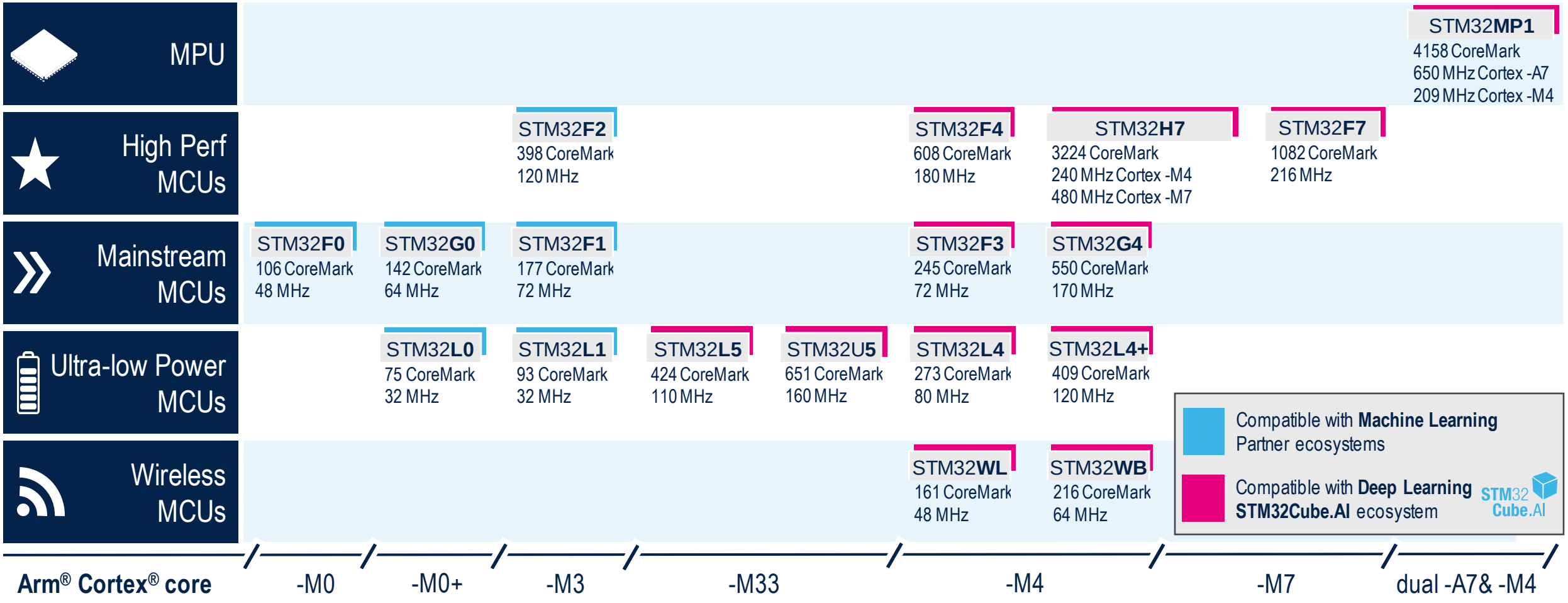
STM32 Cube.AI

K
TensorFlowLite
ONNX
PyTorch
MATLAB

https://github.com/openmv/openmv

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

life.augmented

Function Packs

life.augmented

AI Solutions on STM32

A full development ecosystem to create your AI application

STM32 Cube.AI

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

STM32 **Community** with dedicated Neural Networks topic and **AI expert partners**

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

FP-AI-VISION1

Person presence detection

Food classification

FP-AI-SENSING1

People activity recognition

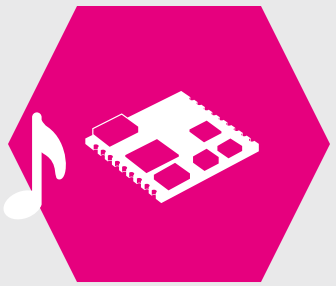
Audio scene classification

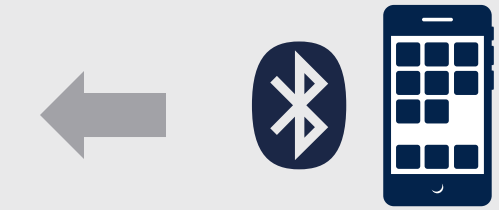
FP-AI-NANOEDG1

Condition-based monitoring

life.augmented

Audio scene classification (ASC)





3 classes

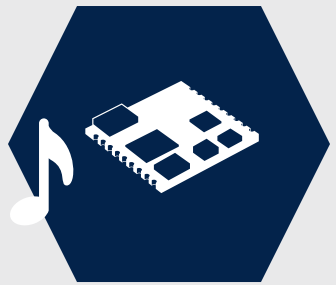
Indoor, Outdoor, In vehicle

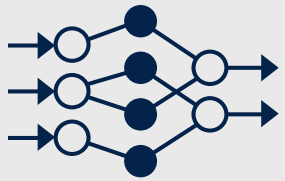
labelling

Audio **Data capture**

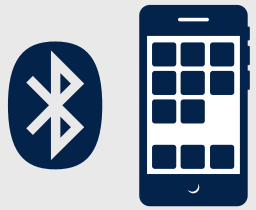
Labelling controlled
by smartphone application

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





NN & example
dataset provided



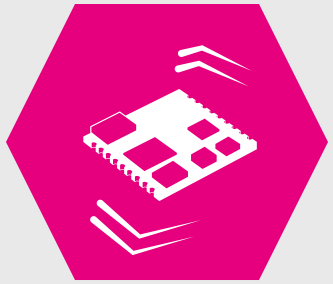
Embedded **audio**
pre-processing

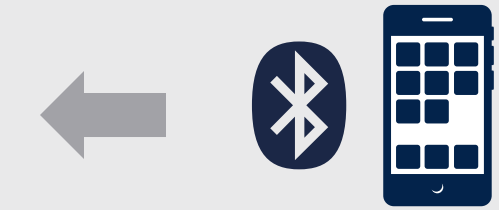
Inferences running
on the microcontroller

Inference result
displayed on mobile app

▶ Demo available

Human activity motion recognition (HAR)





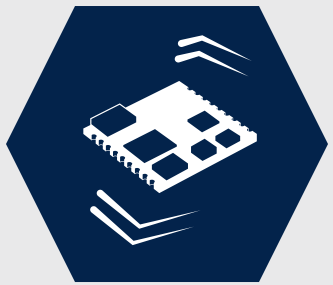
5 classes example

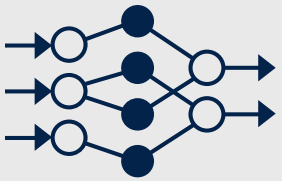
Motion **Data Capture**

Labelling controlled
by smartphone application

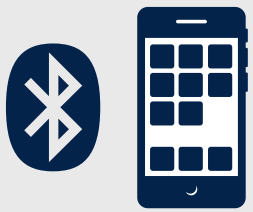
Data stored on the device
SD card for future **learning**

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

life.augmented

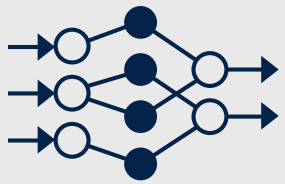
Image classification

Enjoy the food classification demo

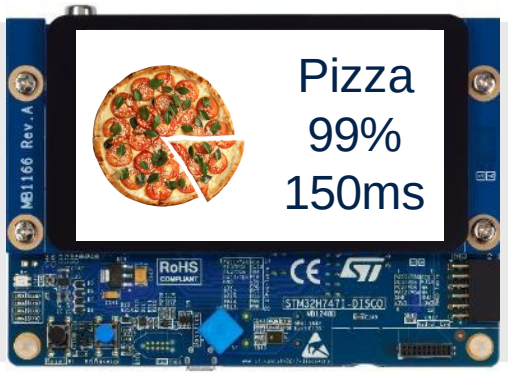
- Default demo based on 18 classes (224x224 RGB pictures)
- Several camera image output size possible

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

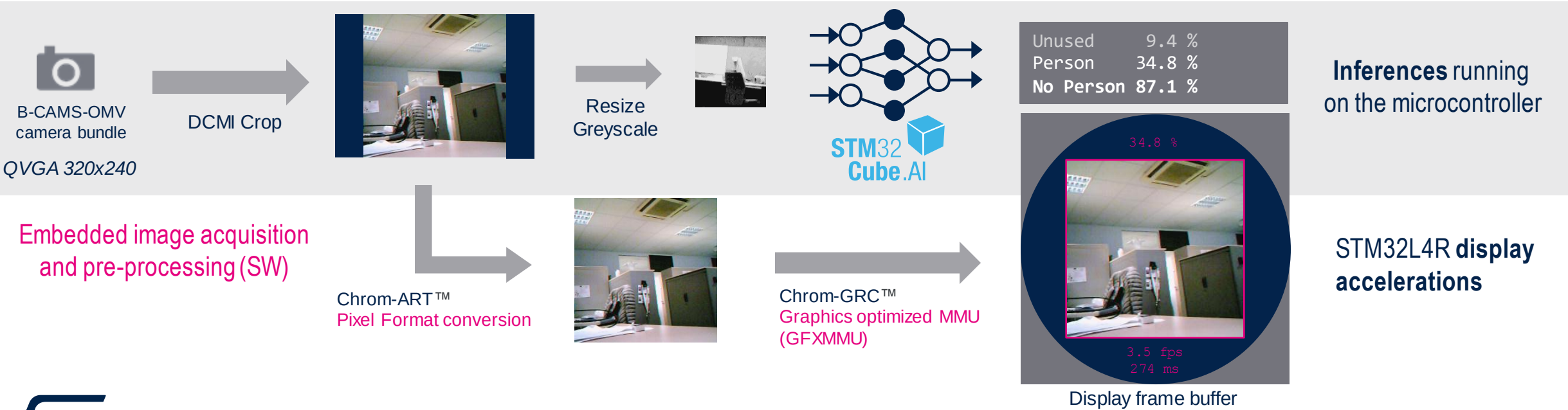
Person presence detection

One-class image classification demo

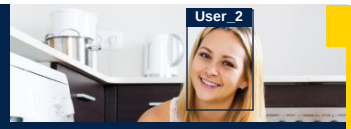
- Models from tensorflow.org (L4R and H7) and MobileNet v2 (H7 only)
- QVGA 320x240 color image on the LCD
- Can adapt camera flipping depending on which side camera is placed

Full end-to-end optimized software example

- from camera acquisition to image pre-processing before feeding the NN
- Multiple models fitting STM32L4R to STM32H7 depending on required performance and cost
- Visual wake word for Smart home or cities security cameras
- Reduce false alarms due to object movement detection

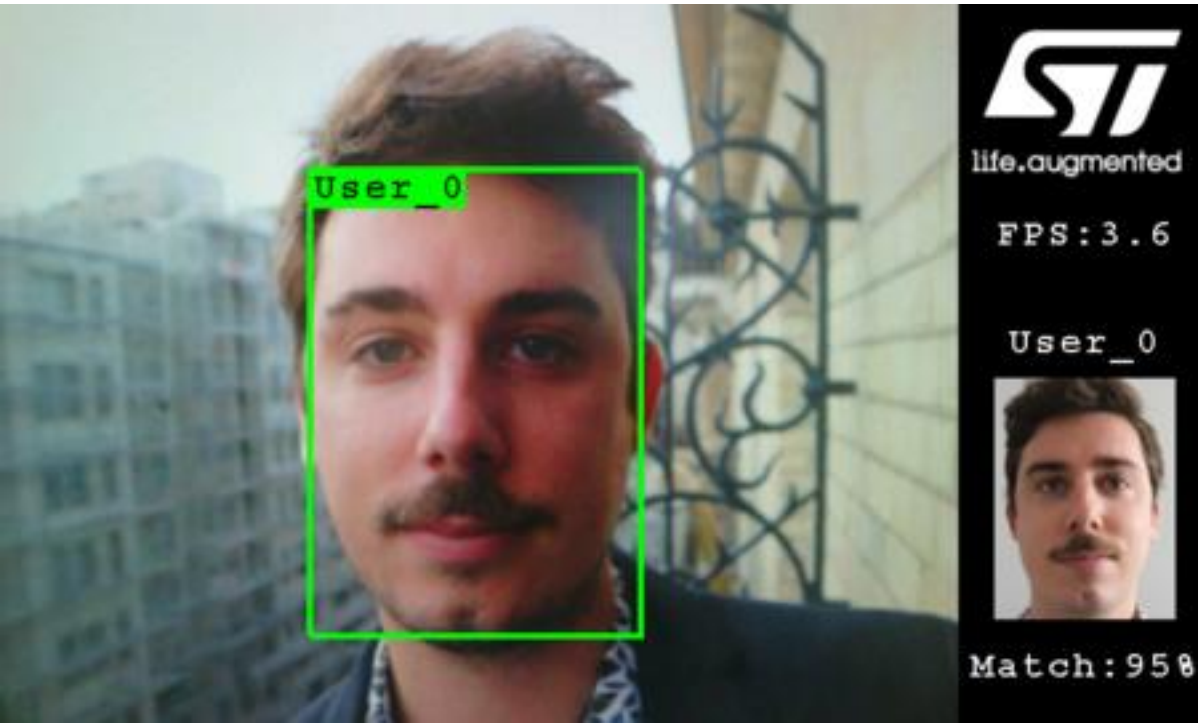


► H7 demo available on FP-AI-VISION1



FP-AI-FACEREC1

Embed face recognition in your IoT project



STM32**H7**

User-personalized services / features

Adjust automatically per user

- Device **preferred settings** or **ergonomics** per user
- Customized device **behavior** / action for registered user
- Customize **alerts**
- **Prevent child injury** with underage appliance lock
- Create user-specific **automations**

Features

- On-device face enrollment of multiple users
- Real-time face recognition, display enrolled image
- Displays match accuracy and inference speed

Available on-demand as a software library
Contact edge.ai@st.com to get access

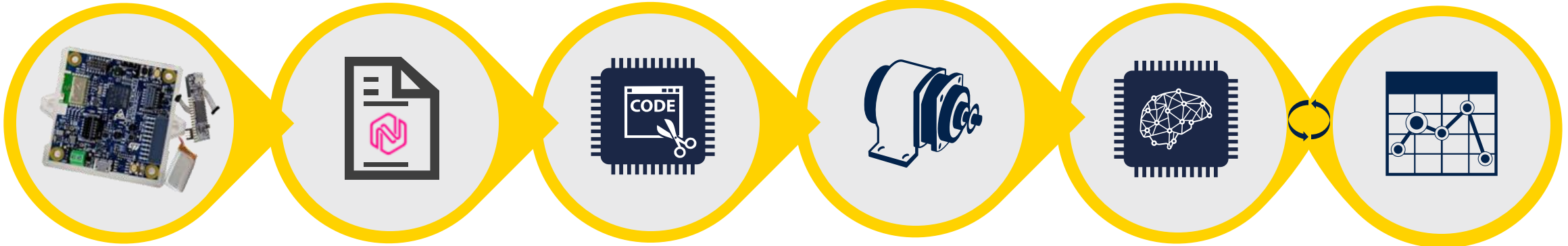
life.augmented

FP-AI-NANOEDG1

Condition monitoring on STWIN

Get straight to proof-of-concept with full anomaly detection system without deep Data Science knowledge

NANOEDGE AI STUDIO By Cartesiam



Collect dataset from industrial-grade vibration sensor

Generate free ML library

Integrate and deploy

Install on premise

Incremental learning on-target

Monitor anomalies on-target

Download the dedicated SW package

life.augmented

AI solutions for STM32MP1

life.augmented

STM32MP1 microprocessor
Augmented intelligence

STM32**MP1** =

Cortex-M4
Realtime OS
STM32CubeMX

+

Dual Cortex-A7
OpenSTLinux Distribution
STM32CubeMx

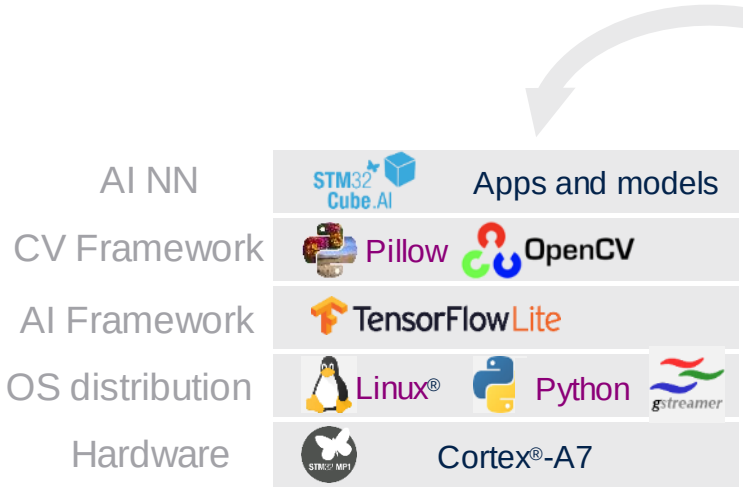
STM32 Cube.AI

X-LINUX-AI
support for
TensorFlowLite
&
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

life.augmented

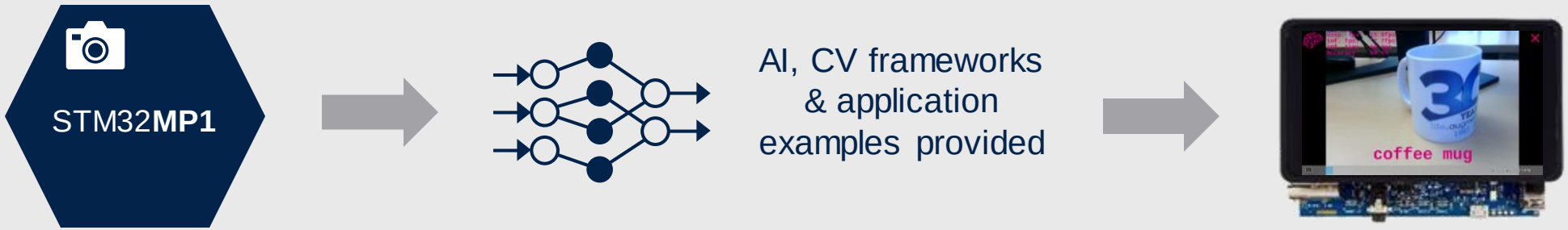
X-LINUX-AI Package for STM32MP1 AI Applications



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 STM32MP157-DK2, STM32MP157-EV1 and Avenger96 board

► 2x demos available

life.augmented

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

Multiple object detection with thermal imager

Partner Program

Meet our expert AIS partners

Visit st.com/stm32cubeai

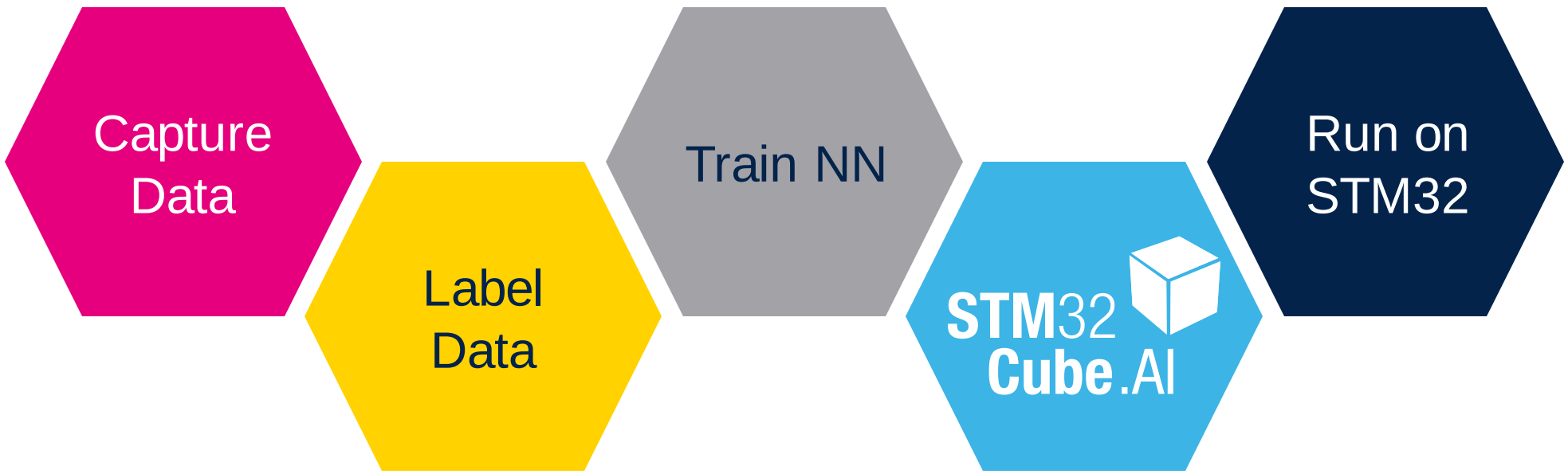
Predictive maintenance of reflow oven

https://www.st.com/content/st_com/en/campaigns/artificial-intelligence-at-the-edge.html

For more information

www.st.com/STM32CubeAI

Contact us at edge.ai@st.com



life.augmented

Releasing your creativity

/STM32

@ST_World

community.st.com

www.st.com/STM32CubeAI

life.augmented

Thank you

life.augmented