



DesignNews

Machine Learning Application Design using STM32 MCU's

DAY 1 : Introduction to Machine Learning on MCU's

Sponsored by



Webinar Logistics

- Turn on your system sound to hear the streaming presentation.
- If you have technical problems, click “Help” or submit a question asking for assistance.
- Participate in ‘Group Chat’ by maximizing the chat widget in your dock.
- Submit questions for the lecturer using the Q&A widget. They will follow-up after the lecture portion concludes.

THE SPEAKER



Jacob Beningo

Visit 'Lecturer Profile'

Beningo Embedded Group - President

Focus: Embedded Software Consulting

An independent consultant who specializes in the design of real-time, microcontroller based embedded software.

He has published two books:

- [Reusable Firmware Development](#)
- [MicroPython Projects](#)

Writes a weekly blog for DesignNews.com focused on embedded system design techniques and challenges.

Visit www.beningo.com to learn more ...

Visit 'Lecturer Profile' in your console for more details.

Course Sessions

- Introduction to Machine Learning on MCU's
- Capturing, Cleaning and Labeling Data
- Training a Neural Network Part 1
- Training a Neural Network Part 2
- Running an Inference on Target

Challenges Facing Embedded Software Developers

Quality



- Buggy software
- Constant bug fixes
- Customer complaints

Development Costs



- Smaller budgets
- More features
- Increased complexity

Time to Market



- More debugging
- Missed deadlines
- Integration woes

Scalable Solutions

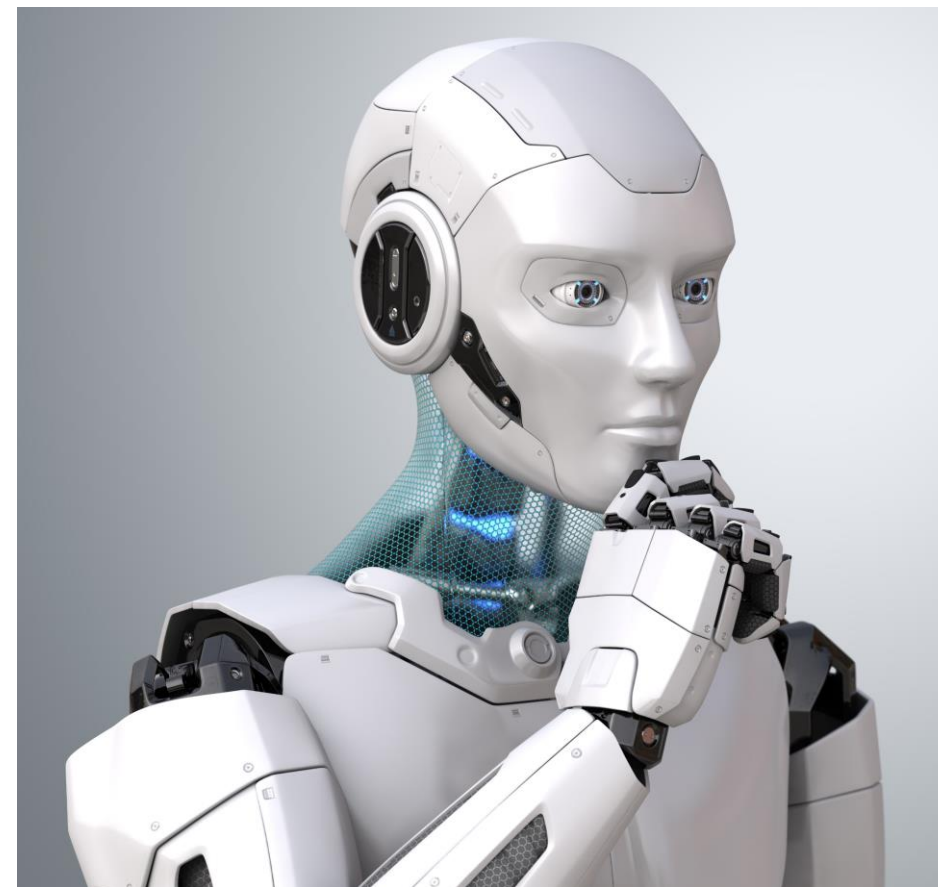


- Tightly coupled code
- Vendor dependency
- Inflexible architecture

What is machine learning?

“Machine learning is a field of computer science that often uses statistical techniques to give computers the ability to ‘learn’ with data, without being explicitly programmed”

- Wikipedia



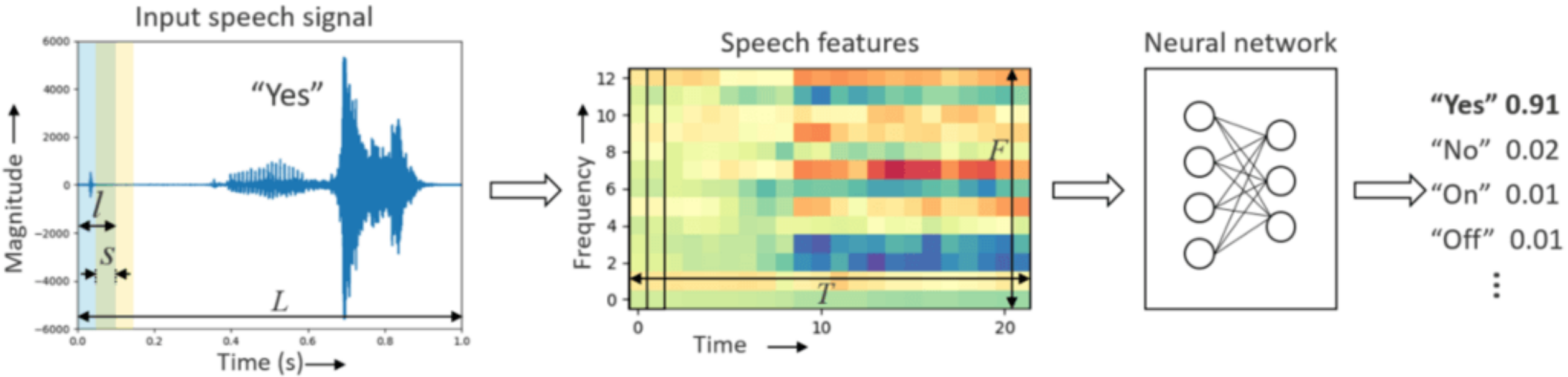
Why is ML Moving to the Edge?

**Bandwidth****Power****Cost****Latency****Reliability****Security**

How experienced are you with Machine Learning?

- Zero Experience
- Have done some light reading
- Trained a model
- Deployed to a microcontroller
- Other

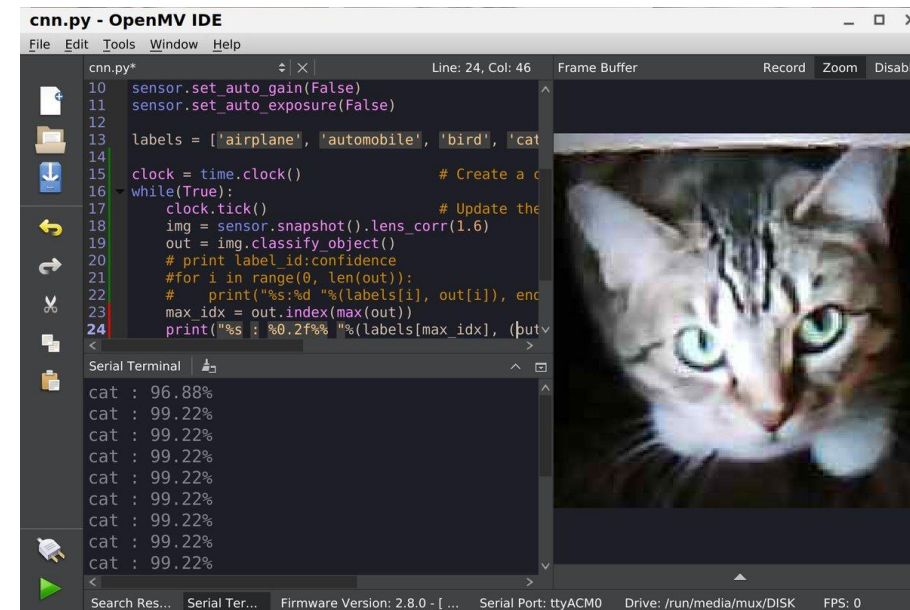
Machine Learning Application #1 – Keyword Spotting



Machine Learning Application #2 – Image Recognition



OpenMV Cam with a Cortex-M7



The screenshot shows the OpenMV IDE interface. The main window displays a Python script named 'cnn.py' with the following code:

```
10 sensor.set_auto_gain(False)
11 sensor.set_auto_exposure(False)
12
13 labels = ['airplane', 'automobile', 'bird', 'cat']
14
15 clock = time.clock() # Create a clock
16 while(True):
17     clock.tick() # Update the clock
18     img = sensor.snapshot().lens_corr(1.6)
19     out = img.classify_object()
20     # print label_id:confidence
21     #for i in range(0, len(out)):
22     #     print("%s:%d"%(labels[i], out[i]), end=" ")
23     max_idx = out.index(max(out))
24     print("%s : %0.2f%%"%(labels[max_idx], (butv
```

Below the code is a Serial Terminal window showing the output of the script:

```
cat : 96.88%
cat : 99.22%
cat : 99.22%
cat : 99.22%
cat : 99.22%
cat : 99.22%
cat : 99.22%
cat : 99.22%
cat : 99.22%
```

On the right side of the IDE, there is a live camera feed showing a close-up of a tabby cat's face.

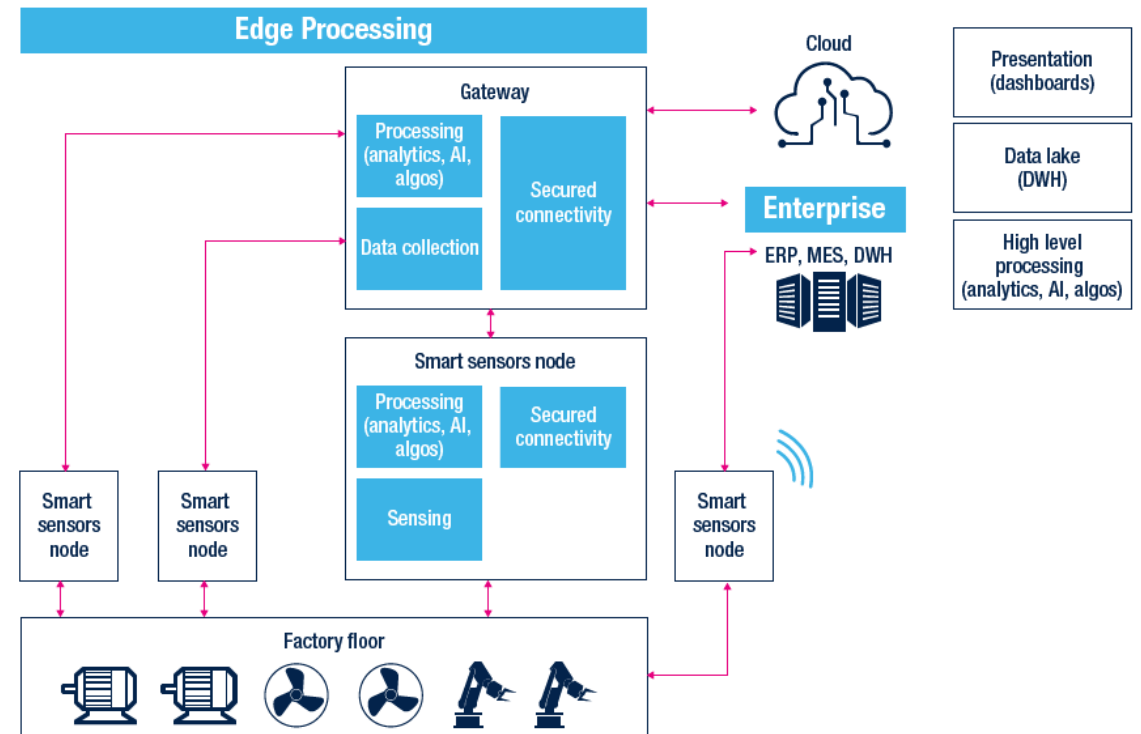
Video :

https://www.youtube.com/watch?v=PdWi_fvY9Og

Machine Learning Application #3 – Predictive Maintenance

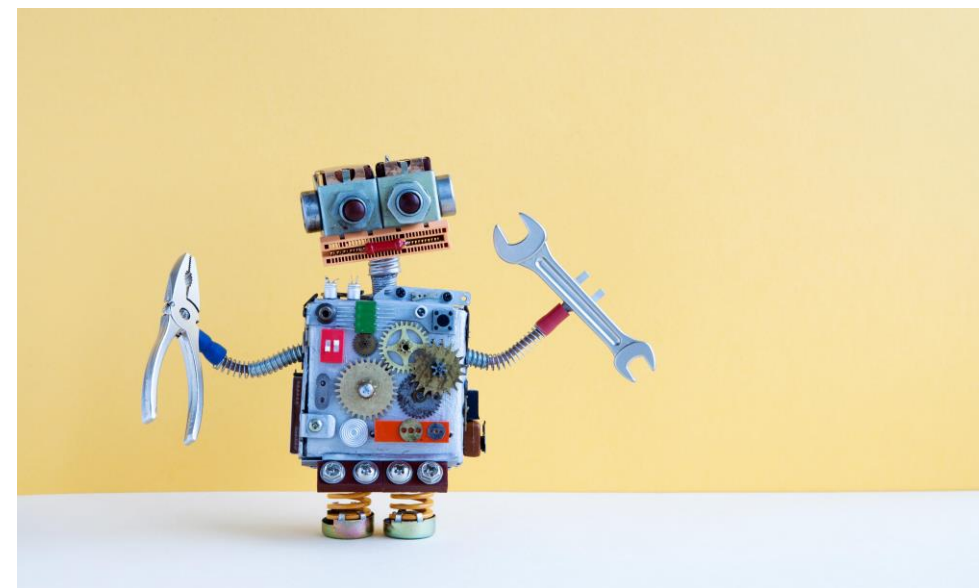
Predictive Maintenance uses tools such as statistical analysis and machine learning to predict equipment state based on:

- Abnormality detection
- Classification algorithms
- Predictive models



Machine Learning Application #X – Choose your own adventure!

- Gesture classification
- Anomaly detection
- Analog meter reader
- Guidance and Control (GNC)
- Game AI
- Package detection
- (a plethora of applications)



What application are you most interested in using Machine Learning for?

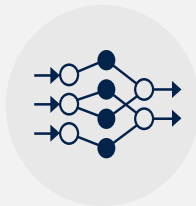
- Keyword spotting
- Image classification
- Predictive maintenance
- Other

5 Steps to Deploy a Neural Network using STM32Cube.AI



Implementing Neural Networks on STM32 MCUs

Train Neural Network using
any major AI frameworks



TensorFlow Lite

ONNX



PyTorch

And more



Convert NN into optimized
code

STM32
Cube.AI

Select most appropriate MCU
Review computation and memory
consumption per layer



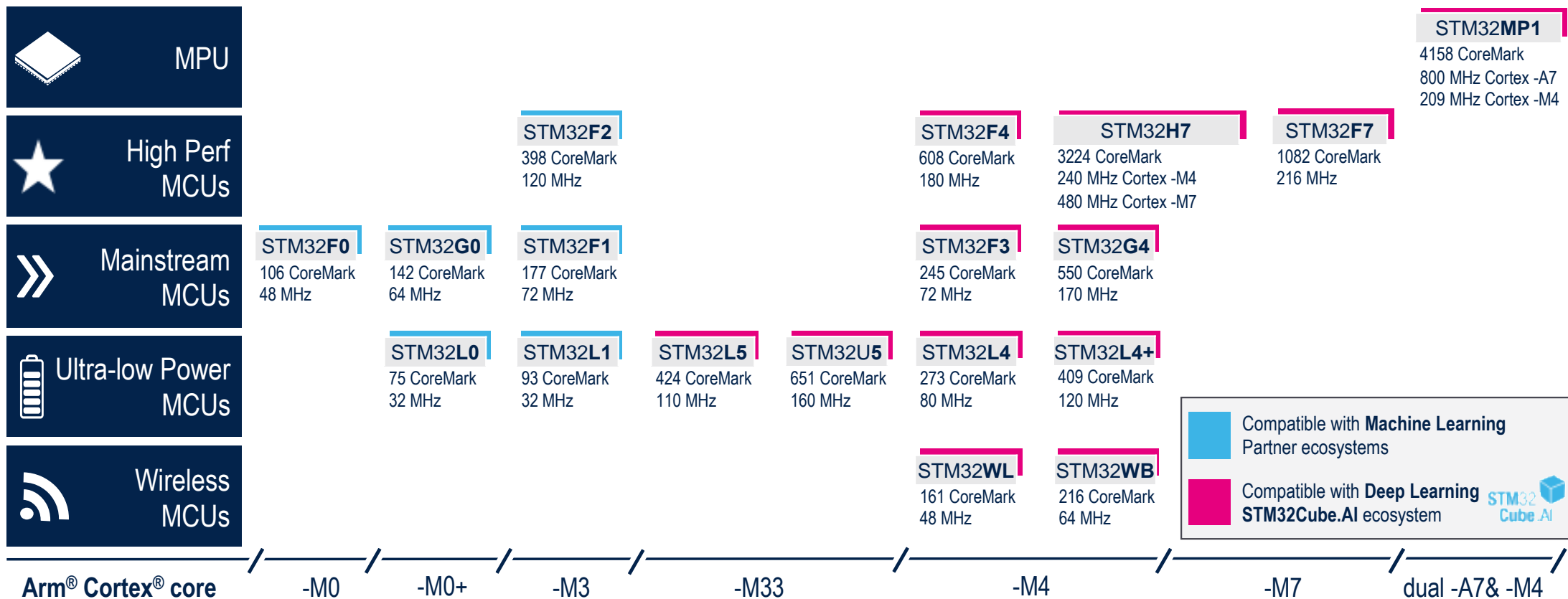
Run on optimized runtime



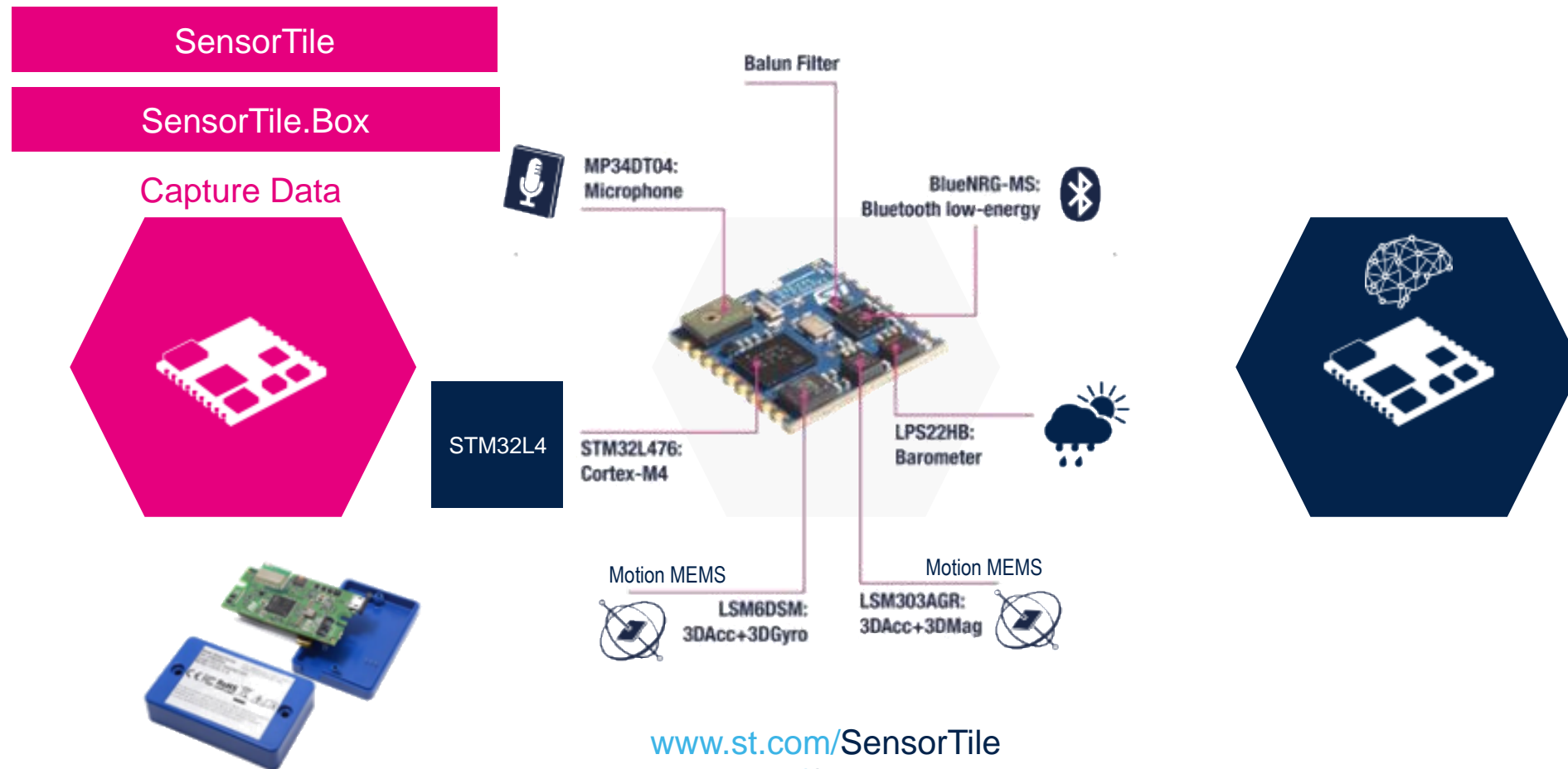
run-time

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

Machine Learning Supported STM32 MCU's



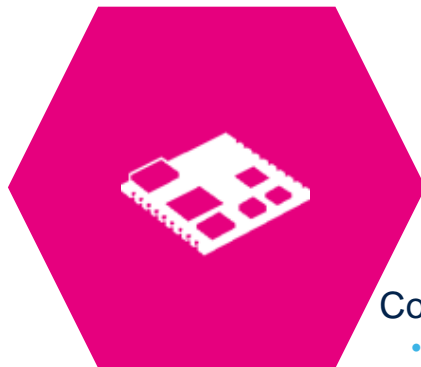
Example STM32 Development Platforms



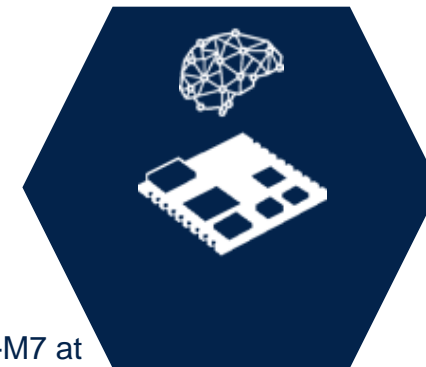
Example STM32 Development Platforms

STM32H747I-DISCO
with B-CAMS-OMV

Capture Data



Inference on STM32H747



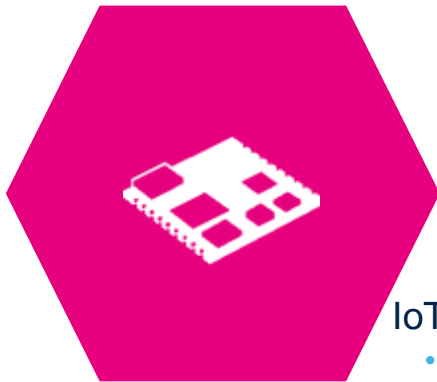
Computer Vision on microcontroller

- 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 WiFi / cellular expansion boards

Example STM32 Development Platforms

STM32L4S5-IOT01A

Capture Data



Inference on STM32L4S5



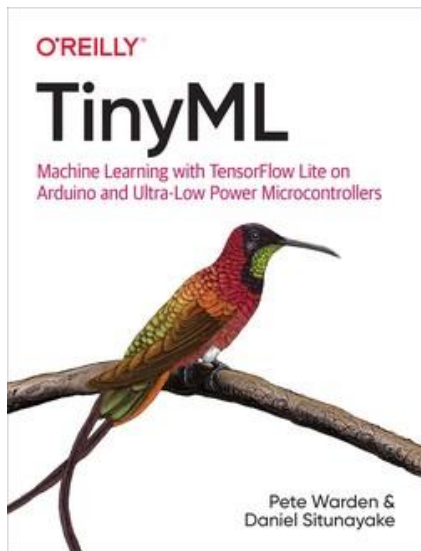
IoT Device Connectivity

- STM32L4+ ultra low-power processor, Arm Cortex-M4 at 120 with 2MB internal Flash, 640kB internal RAM
- 64-Mbit Quad-SPI Flash memory
- 802.11 b/g/n compliant Wi-Fi® module (ISM43362-M3G-L44)
- 2 digital omnidirectional microphones (MP34DT01)
- High-performance 3-axis magnetometer (LIS3MDL)
- 3D accelerometer and 3D gyroscope (LSM6DSL)
- Time-of-flight and gesture-detection sensor (VL53L0X)

What processor family are you interested in trying machine learning on?

- STM32L4+
- STM32F7
- STM32H7
- Other

Machine Learning Resources



- [O'Reilly TinyML by Pete Warden and Daniel Situnayake](#)
- [Pete Warden's Blog](#)
- [Machine Learning On Cortex-M Processors White Paper](#)
- [Image Recognition on Arm Cortex-M with CMSIS-NN](#)
- [TensorFlow Lite for Microcontrollers](#)
- [Keras – Deep Learning in Python](#)
- [STM32 Solutions for Artificial Neural Networks](#)
- [Edge Impulse](#)
- [Teachable Machine](#)

Thank you for attending

Please consider the resources below:

- www.beningo.com
 - Blog, White Papers, Courses
 - Embedded Bytes Newsletter
 - <http://bit.ly/1BAHYXm>



From www.beningo.com under

- Blog > CEC – Machine Learning Application Design using STM32 MCUs



DesignNews

Thank You

Sponsored by

