



Artificial Neural Network Mapping Made Simple with the STM32Cube.AI

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Technology Tour 2019

Dallas-Richardson, TX | March 7



Artificial Intelligence (AI)

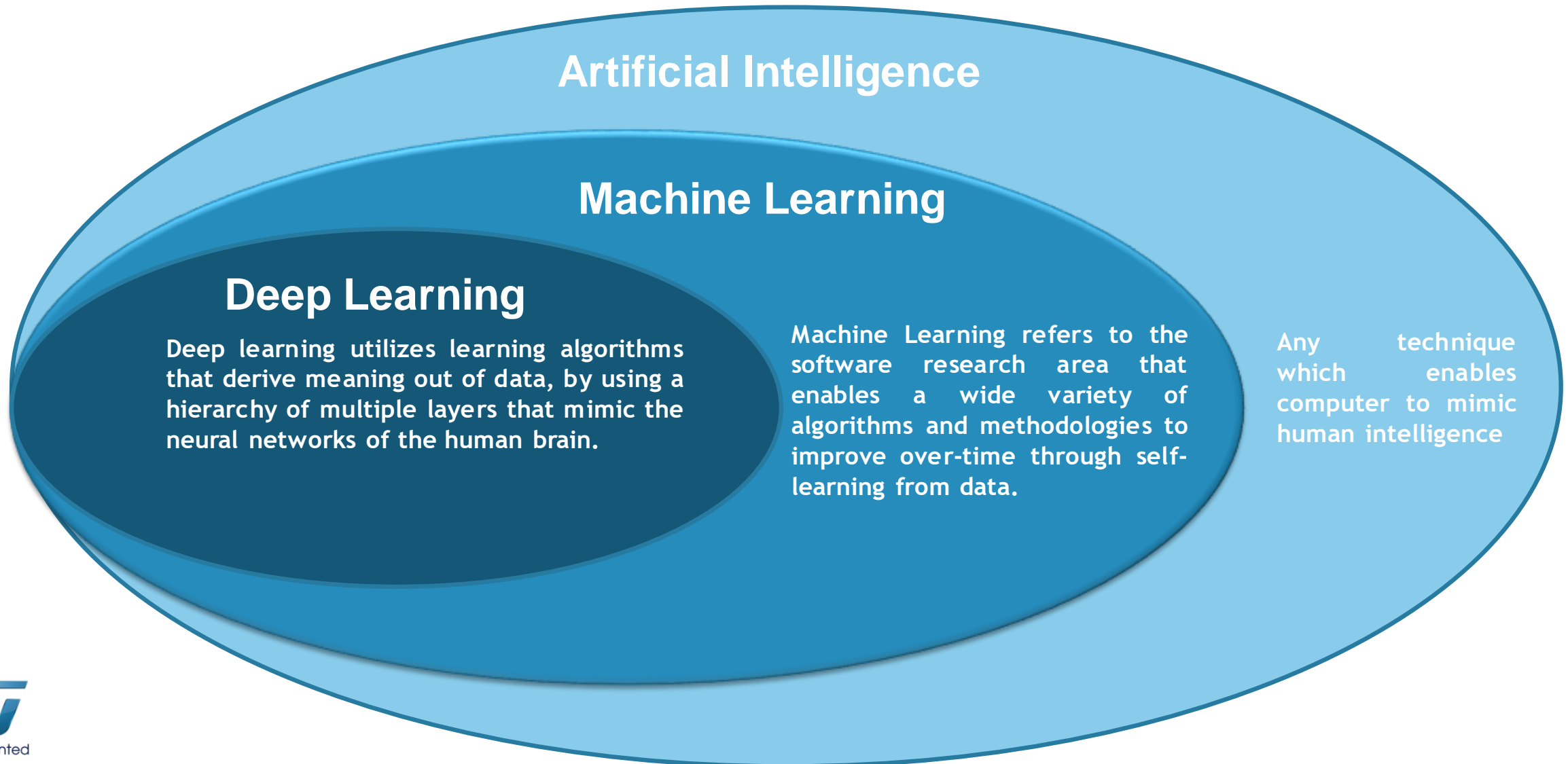
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- AI is a superset of all the studies where machines mimic cognitive capabilities like humans. For example:
 - Interaction with the environment
 - Knowledge representation
 - Perception
 - Learning
 - Computer vision
 - Speech recognition
 - Problem solving and many more.
- Main ingredients
 - Computer science
 - Statistics
 - Mathematics



AI vs Machine Learning vs Deep Learning

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Why Deep Learning is so important

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- Convolutional Deep Neural Networks outperform previous methods on a number of tasks:

Problem	Dataset	Best Accuracy w/o CNN	Best Accuracy with CNN	Diff
Object classification	ILSVRC	73.8%	95.1%	+21.3%
Scene classification	SUN	37.5%	56%	+18.5%
Object detection	VOC 2007	34.3%	60.9%	+26.6%
Fine-grained class	200Birds	61.8%	75.7%	+13.9%
Attribute detection	H3D	69.1%	74.6%	+5.5%
Face recognition	LFW	96.3%	99.77%	+3.47%
Instance retrieval	UKB	89.3% (CDVS: 85.7%)	96.3%	+7.0%

May 2015



Artificial Intelligence and STM32

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Application trend

Sensors



- Activity Recognition with Inertials (DCNN, ESN, LSTM)
- Stress Analysis or Attention Analysis (DCNN, SON), etc

Audio Processing



- Speech Recognition (DeepSpeech, Wave2Letter)
- Speech Synthesis (WaveNet, Tacotron)

Video Analysis



- Classification (Alexnet, Inception, VGG)
- Detection (Yolo, SSD)

STM32



Dedicated AI hardware needed



- Audio use cases with individual commands
- Classic motion sensor use cases

- Video analysis cannot be done in timely manner with MCU
- Advanced Audio use cases with Natural language understanding not yet accessible for MCUs

The Key Steps Behind Neural Networks

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Neural Network (NN) Model Creation



Operating Mode

Capture data



1

2



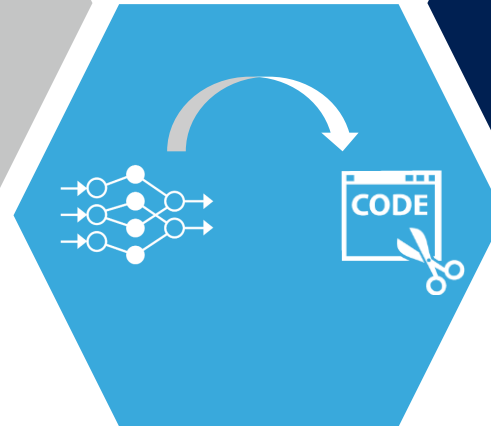
Clean, label Data
Build NN topology

Train NN Model



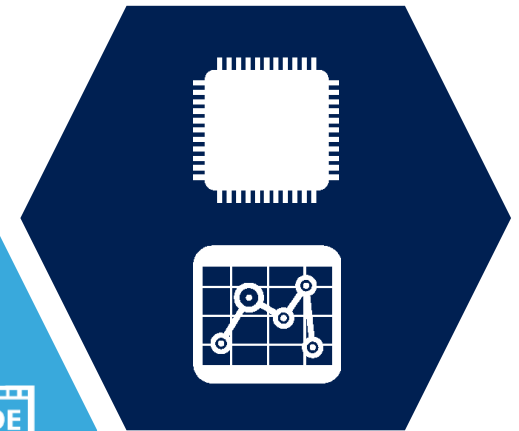
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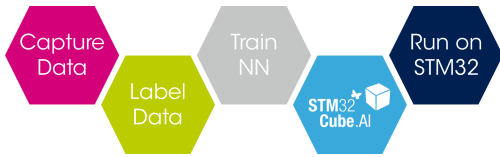


Convert NN into
optimized code for MCU

Process & analyze
new data using trained NN

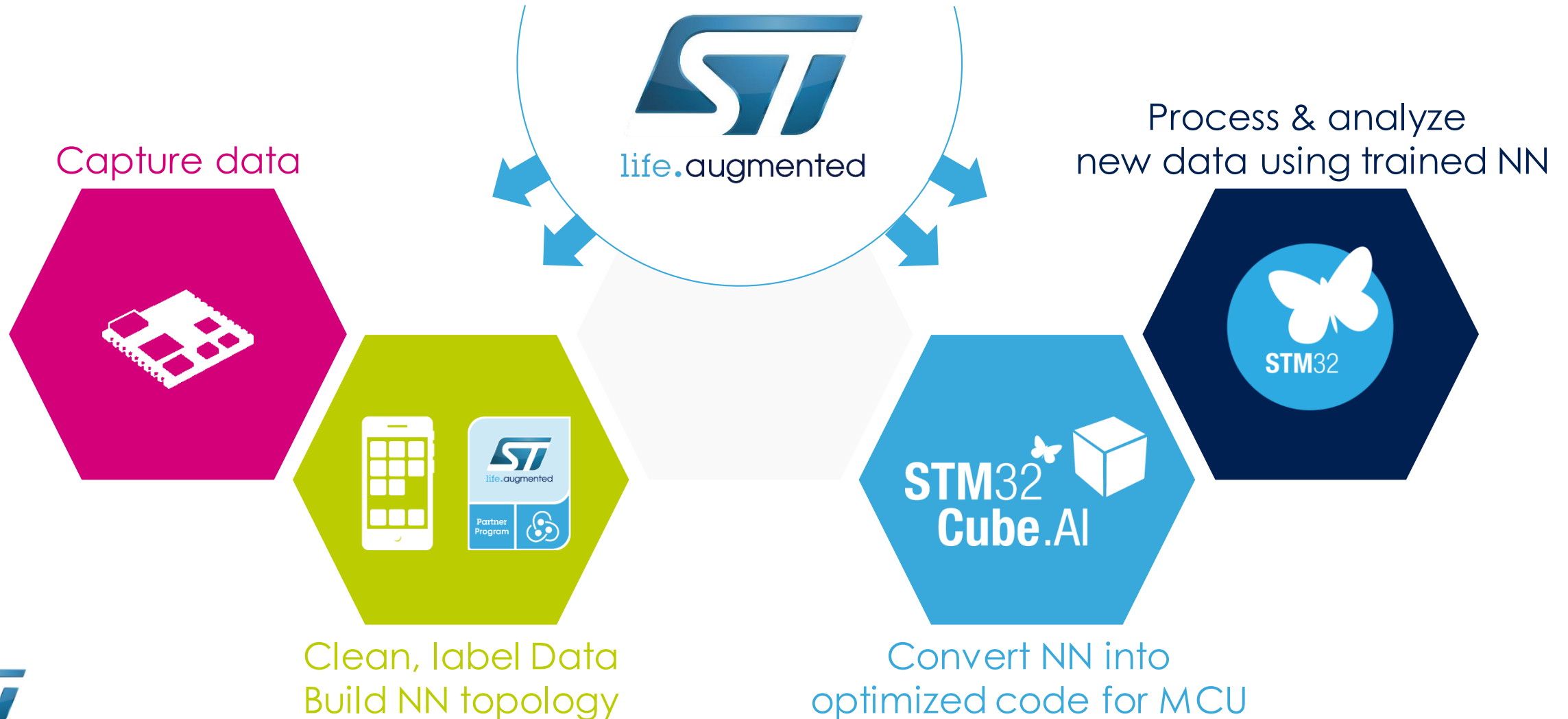


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ST Toolbox for Neural Networks

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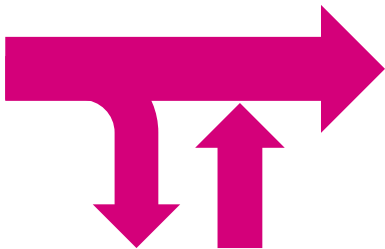
Off-the-shelf :
Pre-trained Artificial
Neural Network Model

Deep Learning
Framework dependent



**Neural
Network
Importer**

Framework
Independent
Artificial Neural
Network
Representation



**Code
Generator**



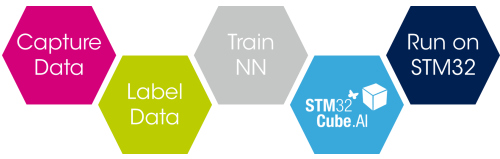
Embedded Solution
Optimized Artificial
Neural Network Code
generated for STM32

Artificial
Neural
Networks
API's

**NN Layers
Library
for STM32**



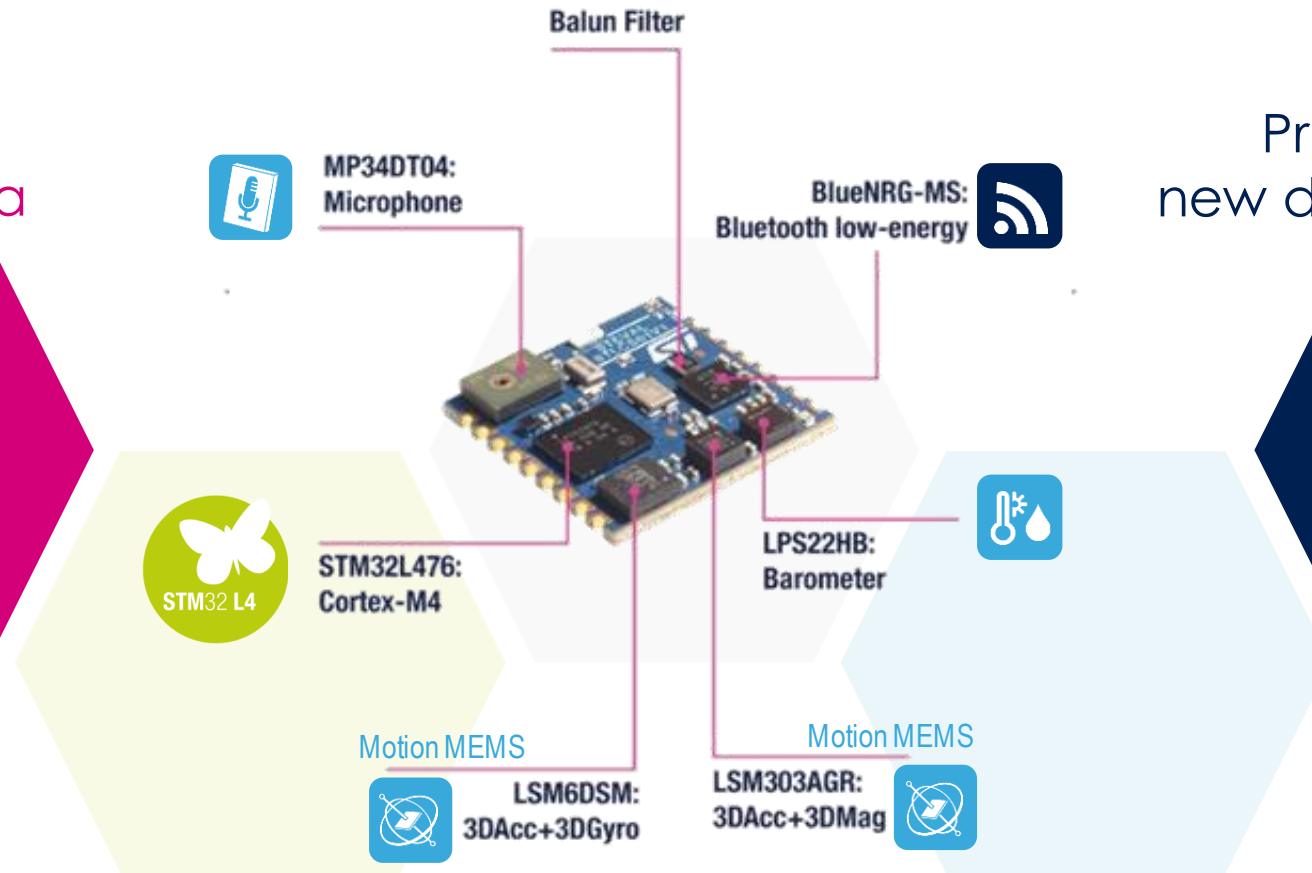
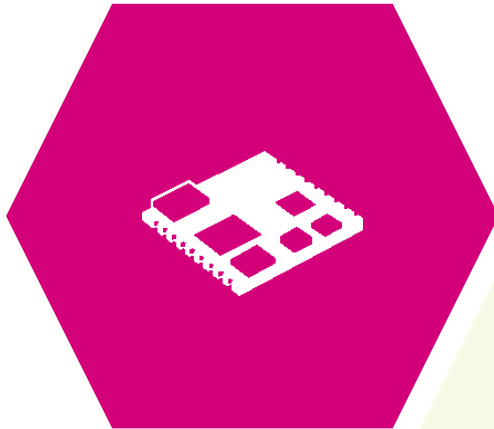
This optimized STM32 Artificial neural network model can be included into the user project (using KEIL, IAR, OpenSTM32) and can be compiled and ported onto the final device for field trials



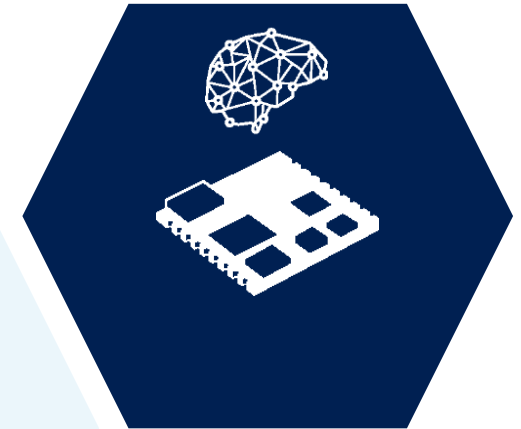
Form Factor Hardware to Capture and Process Data

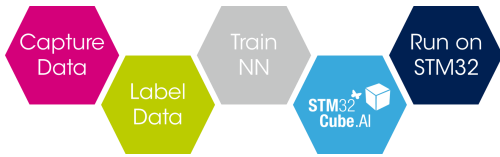
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Capture data



Process & analyze
new data using trained NN



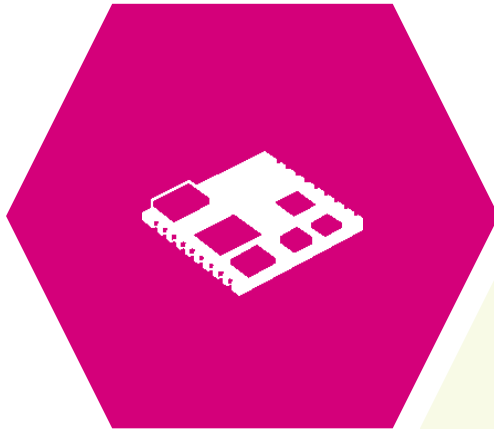


Form Factor Hardware

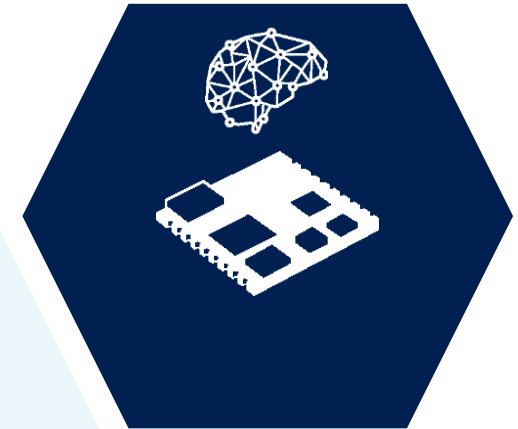
AI IoT Node for More Connectivity (Q1 2019)

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Capture data

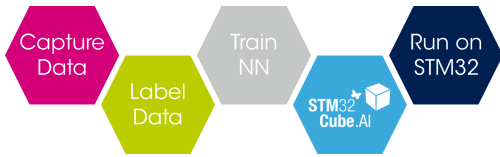


Process & analyze
new data using trained NN



More debug capabilities

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



Collecting Data & Architecting a NN Topology

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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.

www.st.com/STM32CubeAI#MobileApp?



ST BLE
Sensor



Partner
Program



Selected partners

Neural Networks engineering services support.

Data scientists and Neural network architects.

www.st.com/STM32CubeAI#Partners?



STM32CubeMX Extension

AI Conversion Tool

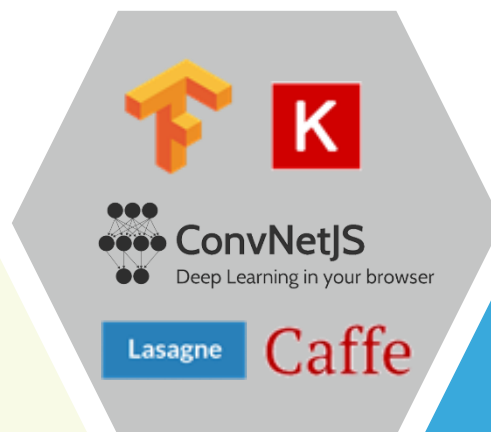
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Input your framework-dependent, pre-trained Neural Network into the **STM32Cube.AI** conversion tool

Automatic and fast generation of an STM32-optimized library

STM32Cube.AI offers interoperability with state-of-the-art Deep Learning design frameworks

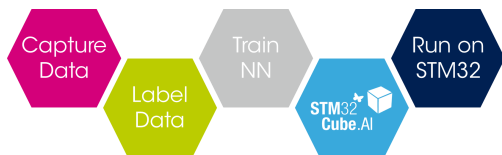
Train NN Model



Process & analyze new data using trained NN



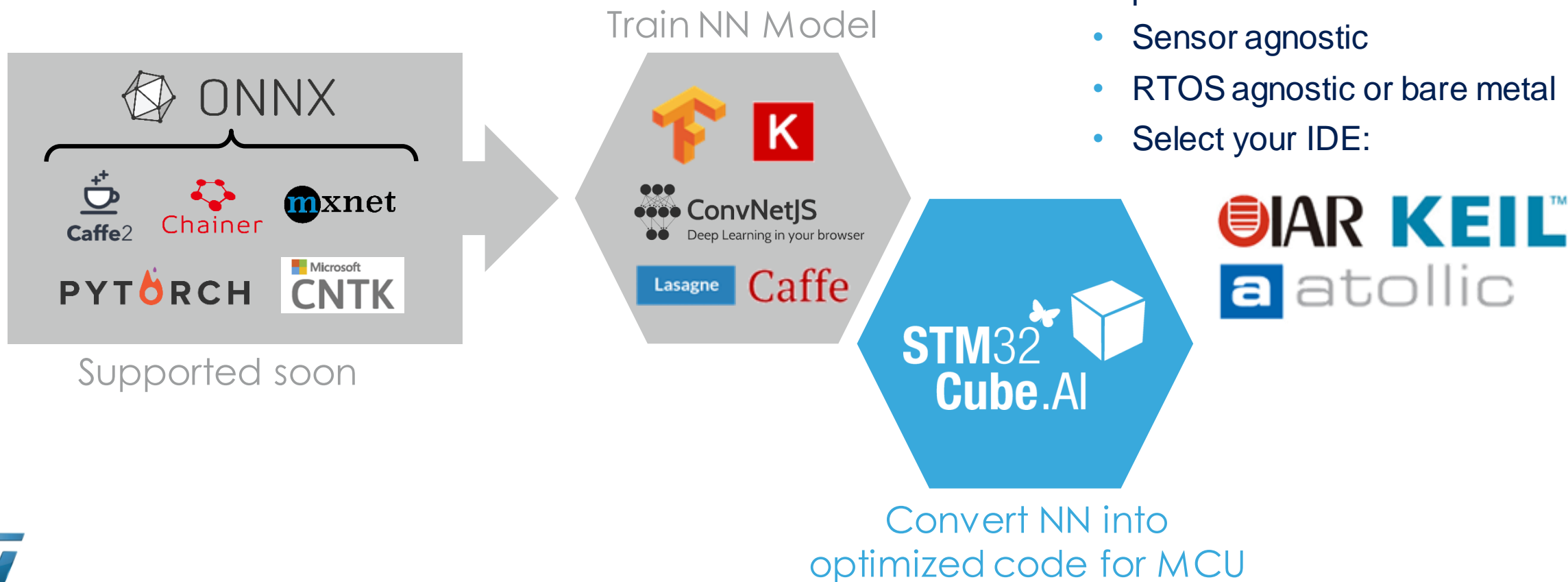
Convert NN into optimized code for MCU

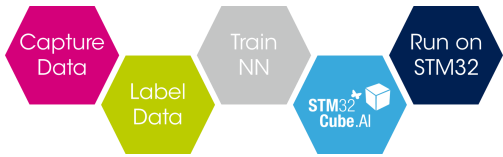


STM32CubeMX Extension

STM32Cube.AI Interoperability

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ST Toolbox for Neural Networks

More Than Just a Conversion Tool

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Resources

- Function packs for **quick prototyping**
- **Audio** and **motion** examples

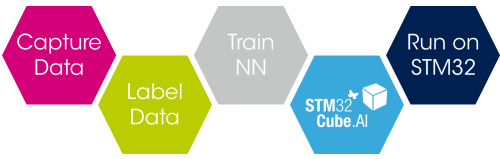


- STM32 **Community** for **support** and **idea** exchange
- **Dedicated** topic for Neural Networks

Process & analyze
new data using trained NN



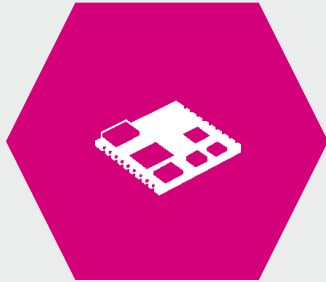
Convert NN into
optimized code for MCU



Human Activity Recognition (HAR)

Motion Example in FP-AI-SENSING1 Package

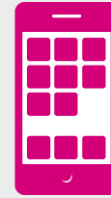
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Embedded **motion**



Labelling controlled
by smartphone application

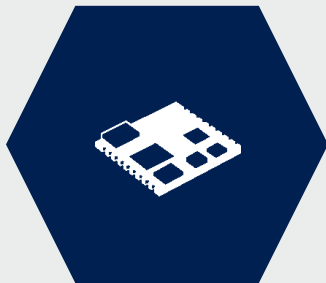


Data stored on the device
SD card for future **learning**



5 classes

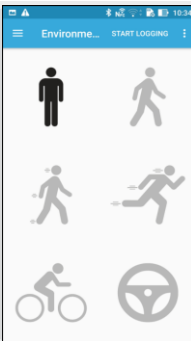
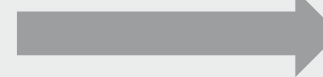
Stationary, walking, running,
biking, driving



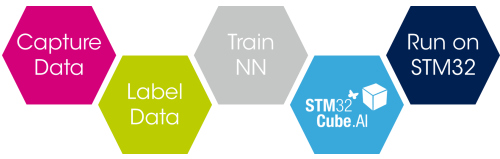
Embedded **motion**
pre-processing



NN & example
dataset provided



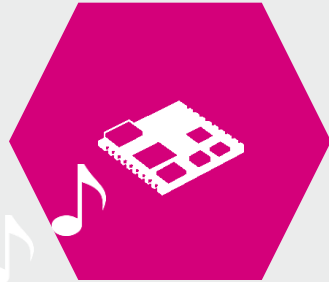
Inference result
displayed on mobile app



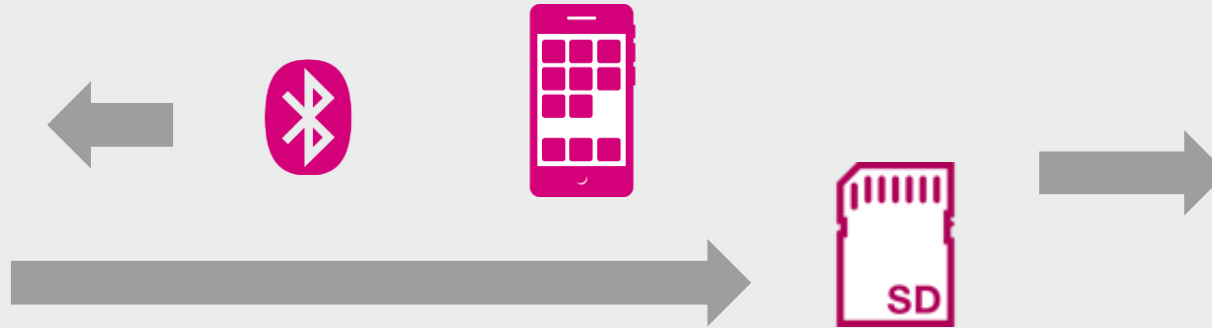
Audio Scene Classification (ASC)

Audio Example in FP-AI-SENSING1 Package

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Embedded audio



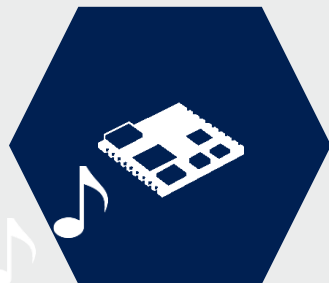
Labelling controlled
by smartphone application

Data stored on the device
SD card for future learning



3 classes

Indoor, Outdoor, In vehicle



Embedded audio
pre-processing

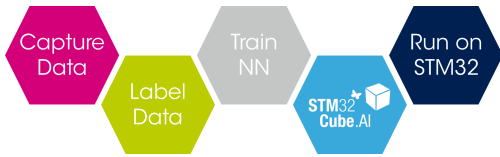


NN & example
dataset provided



Inference result
displayed on mobile app





STM32 Solutions for AI

More Than Just the STM32Cube.AI

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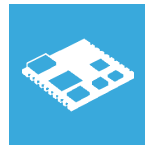
An extensive toolbox to support easy creation of your AI application

AI extension for STM32CubeMX
To map pre-trained Neural Networks onto the STM32



Function packs for Quick prototyping
Audio and motion examples

SensorTile reference hardware
To run inferences or data collection

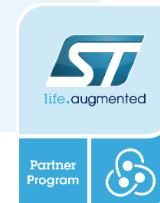


... And more coming!



STM32 Community with dedicated Neural Networks topic

Mobile phone application
To collect and label data
To display the result of inference processing on the STM32



ST Partner Program with a dedicated group of Partners providing Neural Networks engineering services
Data scientists and Neural network architects

For more Information

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www.st.com/STM32CubeAI

