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Quick Start Guide

STM32Cube function pack for ultra-low power context awareness with distributed artificial intelligence (AI): acoustic analysis with NN on MCU and motion analysis with ML on IMU

(FP-AI-CTXAWARE1)

Version 1.0 (May 11, 2021)

Agenda

- 1 Hardware and Software overview
- 2 Setup & Demo Examples
- 3 Documents & Related Resources
- 4 STM32 Open Development Environment: Overview

1- Hardware and Software overview

STEVAL-MKSBOX1V1 evaluation board

Hardware Overview

Multi sensor kit with portable sensor box and smart sensor app Hardware Description

The STEVAL-MKSBOX1V1 (SensorTile.box) is a ready-to-use box kit with wireless IoT and wearable sensor platform to help you use and develop apps based on remote motion and environmental sensor data, regardless of your level of expertise.

The SensorTile.box board fits into a small plastic shroud with a long-life rechargeable battery, and the ST BLE Sensor app on your smartphone connects via Bluetooth to the board and allows you to immediately begin using the wide range of default IoT and wearable sensor applications.

SensorTile.box includes a firmware programming and debugging interface that allows professional developers to engage in more complex firmware code development using the STM32 Open Development Environment (STM32 ODE), which includes a sensing AI function pack with neural network libraries.

Key Product on board

- Ultra-low-power STM32L4 Series MCUs based on ARM® Cortex® -M4 MCU 120 MHz with 2048 kbytes Flash (STM32L4R9ZI)
- Accurate temperature : STTS751
- Low power precise 6x IMU: LSM6DSOX
- Stand-alone XLs: LIS3DHH, LIS2DW12
- Magnetometer: LIS2MDL
- Altimeter / pressure sensor : LPS22HH
- Wide-band microphone: MP23ABS1
- Humidity sensor: HTS221



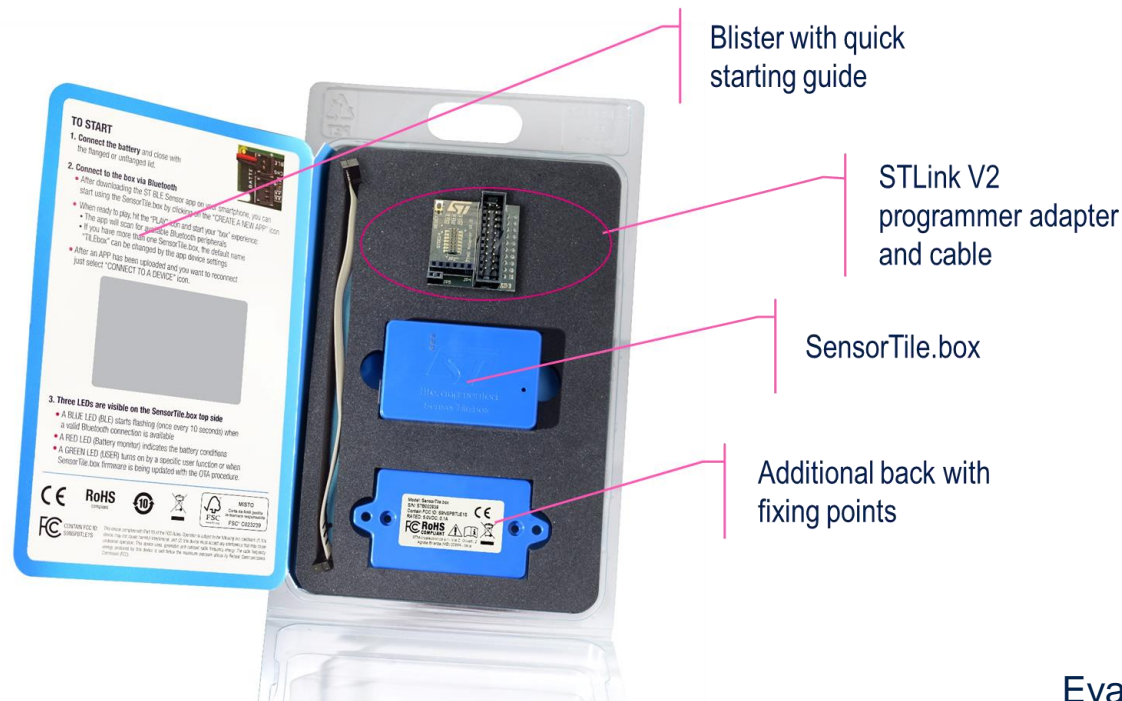
Latest info available at www.st.com
STEVAL-MKSBOX1V1

Hardware Overview

Sample implementations available for: **STEVAL-MKSBOX1V1 evaluation board**

Blister Content:

- STEVAL-MKSBOX1V1 with 2 different cases
- SD-Card and rechargeable battery
- JTAG20 to STDC14 adapter
- STDC14 cable



STEVAL-MKSBOX1V1

FP-AI-CTXAWARE1 Software Description

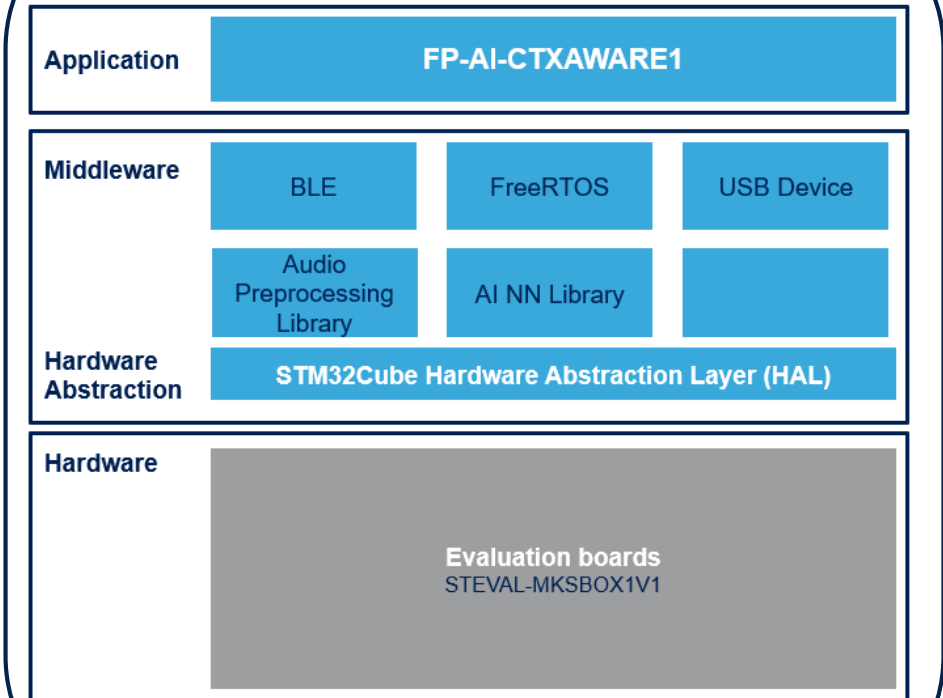
FP-AI-CTXAWARE1 is an STM32Cube function pack featuring example that let you connect your context awareness node to a smartphone via BLE and use an Android™ or iOS™ application such as the ST BLE Sensor app to configure the device or using a Command line interface. The package enables advanced applications such as human activity recognition running inside the Machine Learning Core of LSM6DSOX Component and audio scene classification based on outputs generated by neural network (NN). The software is built on STM32Cube software technology to ease portability across different STM32 microcontrollers.

Key features

- Complete firmware to develop a context awareness node with BLE connectivity, digital microphone, environmental and motion sensors, and perform real-time monitoring of sensors and audio data
- Middleware library generated thanks to STM32CubeMX extension called X-CUBE-AI, featuring example implementation of neural networks for real time acoustic scene classification (ASC) application
- Concurrent execution of several neural networks with concurrent execution of the MLC for HAR and the neural network for ASC
- Ultra-low power implementation based on the use of an RTOS
- Compatible with ST BLE Sensor application for Android/iOS, to perform sensor data reading, audio and motion algorithm feature demo in standalone or combined views, and firmware update over the air
- Sample implementation available for STEVAL-MKSBOX1V1 evaluation boards
- Easy portability across different MCU families, thanks to STM32Cube
- Free, user-friendly license terms

FP-AI-CTXAWARE1 Software Overview

Overall Software Architecture



Latest info available at www.st.com

FP-AI-CTXAWARE1



Context Awareness Activity Recognition: what are we doing?

MCU Audio Scene Classification



Sensor Human Activity Recognition

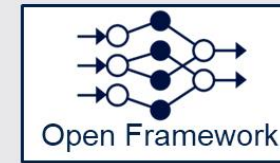
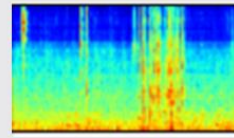


Audio data recording
Pre-processing
DB Preparation of NN Training and Test

Neural Network Topology
Definition, Training and Test
Using existing DL Frameworks

Optimized Neural Network code
automatically generated for STM32

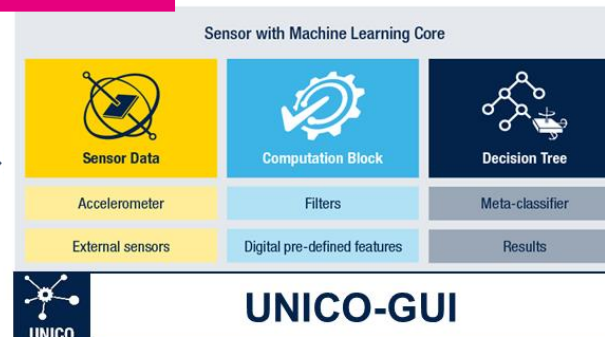
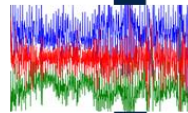
Upload Neural Network
code on STM32 MCU



STM32
Cube.AI



Data collection
Decision Trees generation
and upload in sensor



SensorTile.Box



2- Setup & Demo Examples

Setup & Application Examples

HW prerequisites

- 1x STEVAL-MKSBOX1V1 evaluation board
- Laptop/PC with Windows 7, 8 or 10
- 1 x microUSB cable
- 1x USB type A to Mini-B USB cable
- ST-Link/V2 in-circuit debugger/programmer for STM8 and STM32



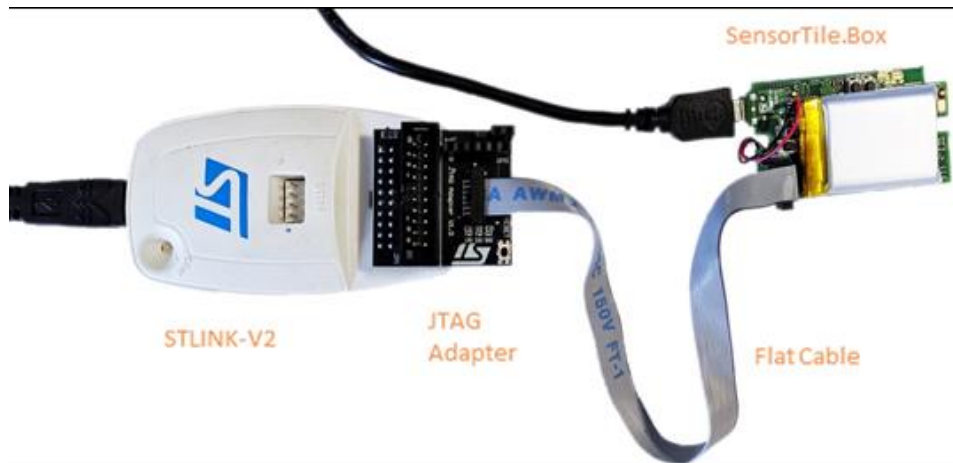
MicroUSB Cable



Mini USB



ST-Link/V2



STEVAL-MKSBOX1V1

Setup & Application Examples

Software and Other prerequisites

- **STM32 ST-Link Utility**

- Download and install STSW-LINK004 from www.st.com

- **FP-AI-CTXAWARE1**

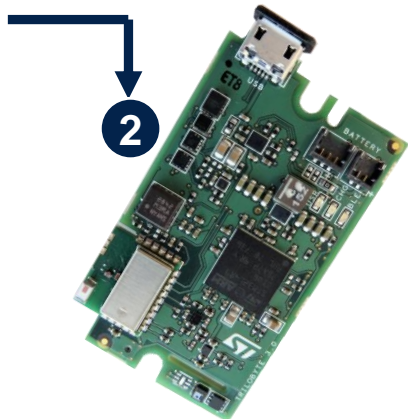
Copy the .zip file content into a folder on your PC. The package will contain source code example (Keil, IAR, STM32Cube IDE) based on **STEVAL-MKSBOX1V1**.

- **ST BLE Sensor Application** for Android or iOS, to download from Google Play Store or Apple App Store
- **Serial line monitor**, e.g. TeraTerm (<https://ttssh2.osdn.jp/>)

FP-AI-CTXAWARE1 Setup Overview



1 www.st.com/stm32code-fp



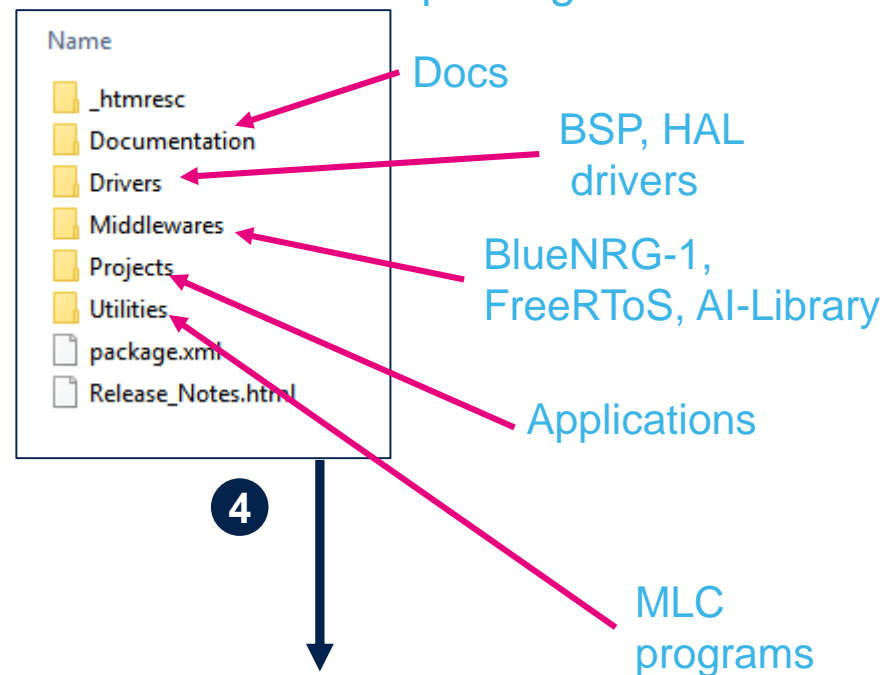
2

3

Download & unpack

Select Function Pack: FP-AI-CTXAWARE1

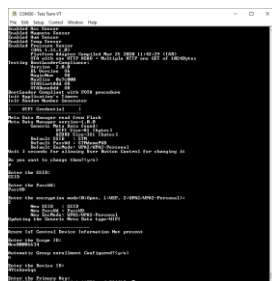
FP-AI-CTXAWARE1 package structure



4

Android™/iOS™ smartphone and
ST BLE Sensor application
Or Serial Line Monitor

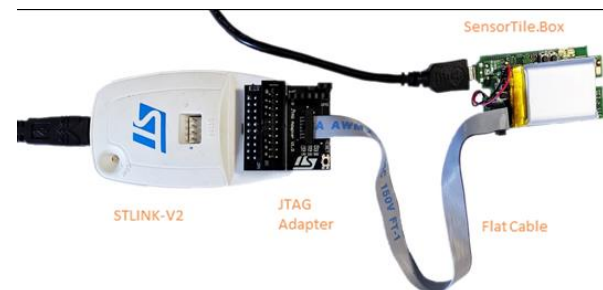
Projects\STM32L4R9ZI-SensorTile.box\Applications\BLELowPower\EWARM
Projects\STM32L4R9ZI-SensorTile.box\Applications\CLAI\EWARM



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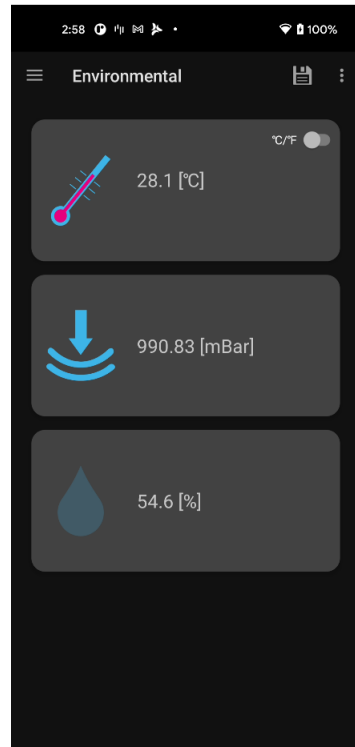


2.1- Using the ST BLE Application (BLELowPower Application)

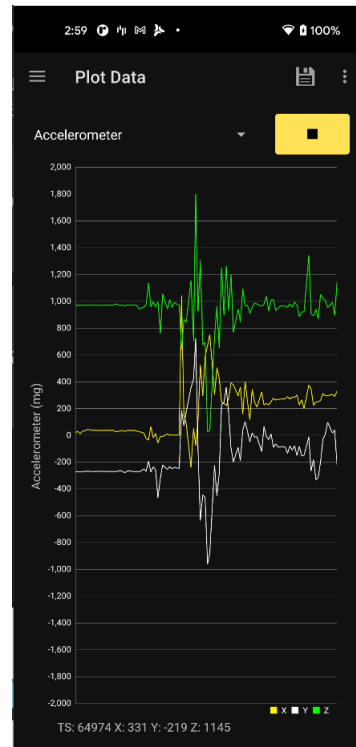
BLELowPower (FP-AI-CTXAWARE1)

BLE version

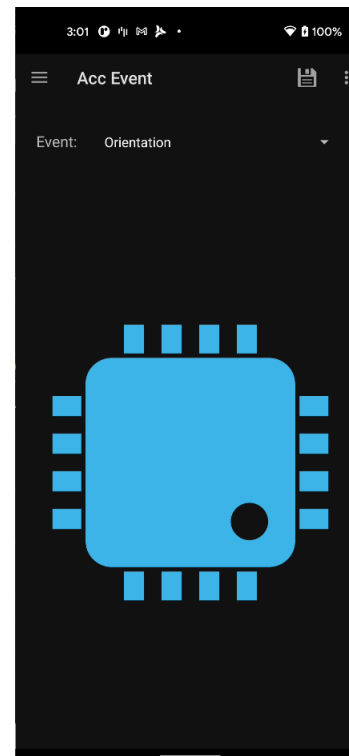
Environmental



Plot



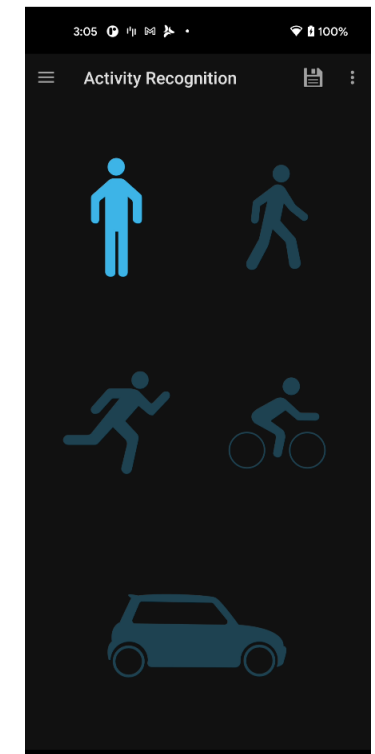
HW Feature



Audio Scene Classification



Activity Recognition



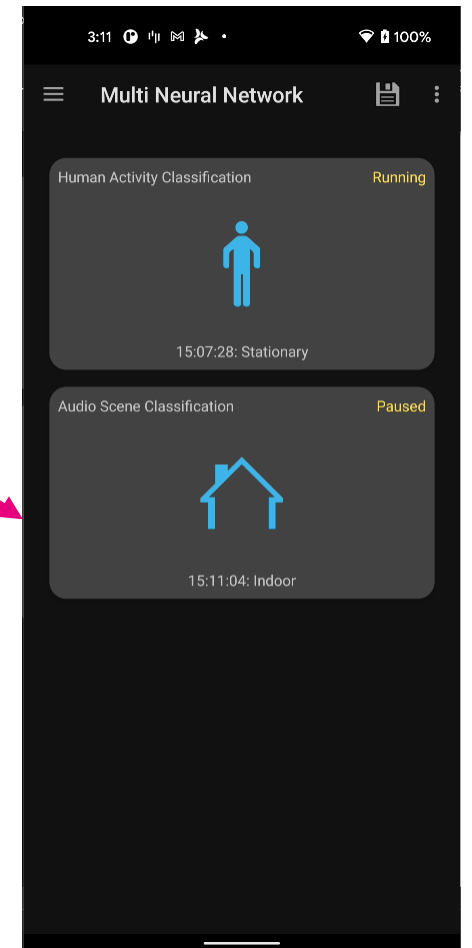
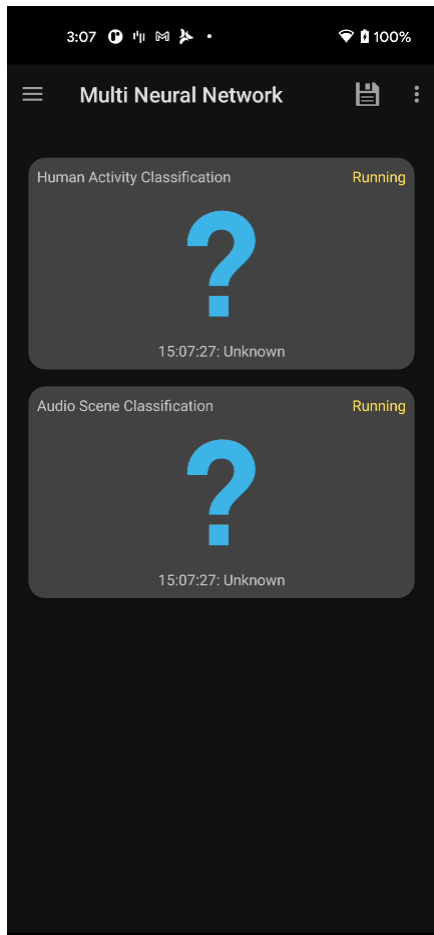
BLELowPower (FP-AI-CTXAWARE1)

BLE version

Human Activity Recognition (HAR) running on MLC provides indication about activity status (“Stationary”, “Walking”, “Jogging”, “Biking”) while Acoustic Scene Classification (ASC) is used for context awareness (“Indoor”, “Outdoor”, “In Vehicle”)

The Human Activity Recognition (HAR) is always running on MLC (LSM6DSOX) without consuming power on STM32

The Acoustic Scene Classification (ASC) runs periodically for controlling the context, and changing the program on MLC if it is necessary



Indoor/ Outdoor	In Vehicle
Stationary	Stationary
Walking	Walking
Jogging	Driving
Biking	

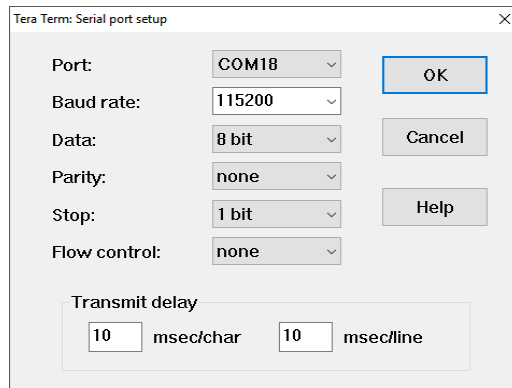
2.2- Using Serial Line monitor – e.g. TeraTerm (CLAi Application)

Command Line AI Application (CLAi) (FP-AI-CTXAWARE1)

Command Line version

Same functionalities as the BLE version

Serial Line
Monitor
Configuration



At the
beginning the
Board will print
out the usage:

```
COM6 - Tera Term VT
File Edit Setup Control Window Help

-----
STMicrollectronics CLAi
Version 1.0.0
STM32L4R9ZI-SensorTile.box board
<HAL 1.12.0_0>
Compiled Apr 28 2021 13:10:09 <IAR>
-----

! HELP: !

ASC StartStop: S/s
MLC StartStop: A/a
ASC/MLC StartStop: M/m
dB Mic StartStop: D/d
Stop Current Mode: C/c
Enter DFU MODE: R/r
Print this HELP: H/h
-----
```

- Using the Command Line interface, it's possible to:
 - run the Acoustic Scene Classification
 - run the Human Activity Recognition
 - Run the Human Activity Recognition and the Acoustic Scene Classification in a combined mode
 - Print out the dB measured by microphone

```
COM6 - Tera Term VT
File Edit Setup Control Window Help

Runtime revision : 6.0.0
Tool revision : <6.0.0>
Network info...
nodes : 9
complexity : 509312 MACC
activation : 9296 bytes
params : 7900 bytes
inputs/outputs : 1/1
I[0] s8, scale=0.313726, zero=127, 960 bytes, shape=(30,32,1)
O[0] s8, scale=0.003906, zero=-128, 3 bytes, shape=(1,1,3)
Initializing the network asc
Activation buffer : 0x200028a0 <9296 bytes> internal
MLC Start
OK Init Accelerometer Sensor
-->Activity Recognition for LSM6DSOX MLC INDOOR and OUTDOOR
Program loaded inside the LSM6DSOX MLC
Enabled LSM6DSOX INT1 Detection
Enabled LSM6DSOX INT2 Detection
ASC= 4% 9% 0%
ASC= 12% 16% 0%
MLC Activity->STATIONARY
ASC= 21% 21% 0%
ASC= 29% 27% 0%
ASC= 35% 35% 0%
```

3- Documents & Related Resources

Documents & Related Resources

All documents are available in the DESIGN tab of the related products webpage

FP-AI-CTXAWARE1:

- **DB4483:** STM32Cube function pack for ultra-low power context awareness with distributed artificial intelligence (AI): acoustic analysis with NN on MCU and motion analysis with ML on IMU – [databrief](#)
- **UM2870:** Getting started with the STM32Cube function pack for ultra-low power context awareness node with artificial intelligence (AI) application based on audio and motion sensing – [user manual](#)
- [Software setup file](#)

STEVAL-MKSBOX1V1:

- [Gerber files, BOM, Schematic](#)
- **DB3903:** SensorTile.box wireless multi sensor development kit with user friendly app for IoT and wearable sensor applications – [databrief](#)
- **UM2580:** How to use the wireless multi sensor development kit with customizable app for IoT and wearable sensor applications – [user manual](#)

4- STM32 Open Development Environment: Overview

FAST, AFFORDABLE PROTOTYPING AND DEVELOPMENT

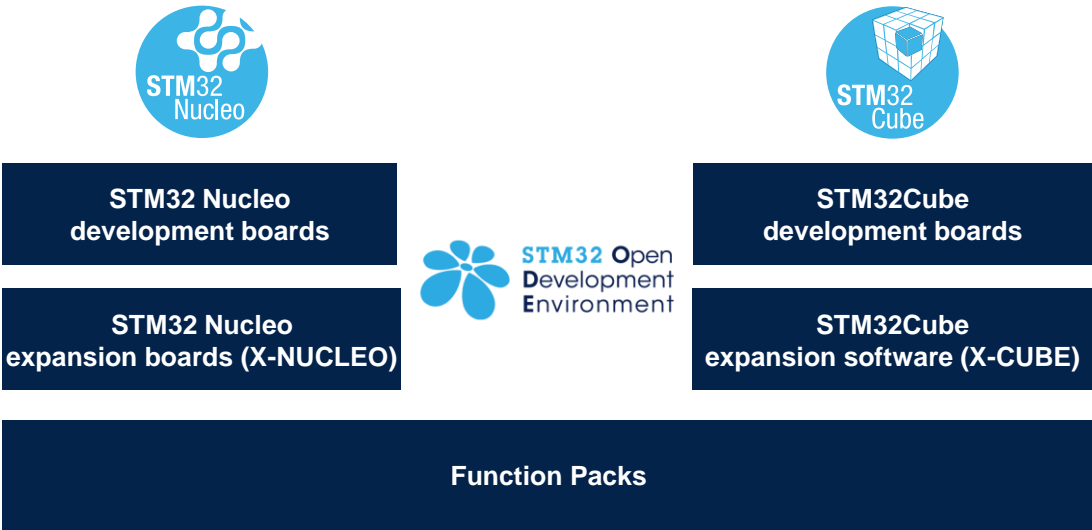
The STM32 Open Development Environment (ODE) is an **open, flexible, easy** and **affordable** way to develop innovative devices and applications based on the STM32 32-bit microcontroller family combined with other state-of-the-art ST components connected via expansion boards. It enables fast prototyping with leading-edge components that can quickly be transformed into final designs.

The STM32 ODE includes the following five elements:

- STM32 Nucleo development boards. A comprehensive range of affordable development boards for all STM32 microcontroller series, with unlimited unified expansion capability, and with integrated debugger/programmer
- STM32 Nucleo expansion boards. Boards with additional functionality to add sensing, control, connectivity, power, audio or other functions as needed. The expansion boards are plugged on top of the STM32 Nucleo development boards. More complex functionalities can be achieved by stacking additional expansion boards
- STM32Cube software. A set of free-of-charge tools and embedded software bricks to enable fast and easy development on the STM32, including a Hardware Abstraction Layer, middleware and the STM32CubeMX PC-based configurator and code generator
- STM32Cube expansion software. Expansion software provided free of charge for use with STM32 Nucleo expansion boards, and compatible with the STM32Cube software framework
- STM32 ODE Function Packs. Set of function examples for some of the most common application cases built by leveraging the modularity and interoperability of STM32 Nucleo development boards and expansions, with STM32Cube software and expansions.

The STM32 Open Development Environment is compatible with a number of IDEs including IAR EWARM, Keil MDK, mbed and GCC-based environments.

STM32 ODE Ecosystem



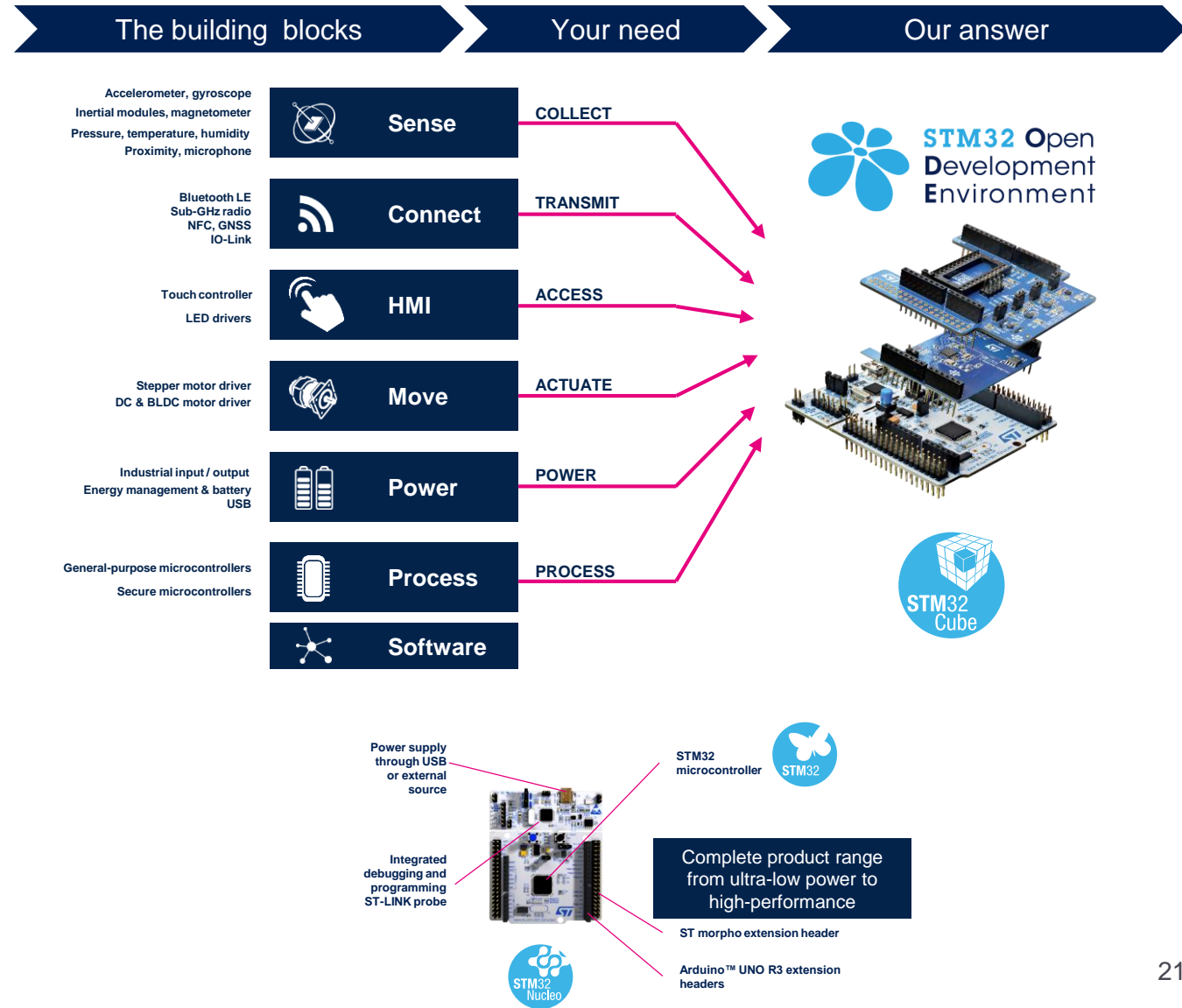
STM32 Open Development Environment: all that you need

The combination of a broad range of expandable boards based on leading-edge commercial products and modular software, from driver to application level, enables fast prototyping of ideas that can be smoothly transformed into final designs.

To start your design:

- Choose the appropriate STM32 Nucleo development board (MCU) and expansion (X-NUCLEO) boards (sensors, connectivity, audio, motor control etc.) for the functionality you need
- Select your development environment (IAR EWARM, Keil MDK, and GCC-based IDEs) and use the free STM32Cube tools and software.
- Download all the necessary software to run the functionality on the selected STM32 Nucleo expansion boards.
- Compile your design and upload it to the STM32 Nucleo development board.
- Then start developing and testing your application.

Software developed on the STM32 Open Development Environment prototyping hardware can be directly used in an advanced prototyping board or in an end product design using the same commercial ST components, or components from the same family as those found on the STM32 Nucleo boards.



Thank you

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