FP-AI-PDMWBSOC2
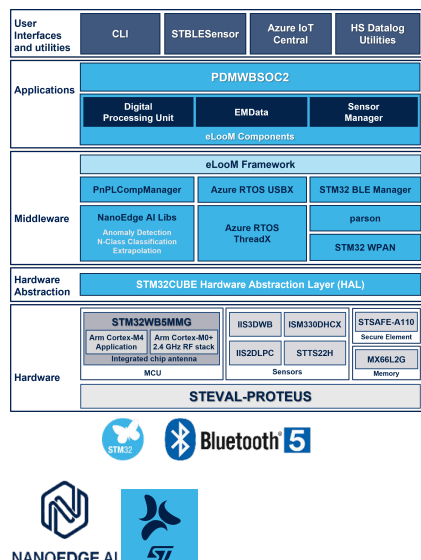
STM32Cube function pack for STEVAL-PROTEUS1 for AI anomaly detection, classification and extrapolation based on AzureRTOS

Features

- Firmware to develop a WPAN sensor node for predictive maintenance applications, featuring motion sensors and performing anomaly detection, classification and extrapolation controlled via Bluetooth® Low Energy connectivity
- STM32 wireless personal area network middleware developed within the STM32WB framework used to support Bluetooth® Low Energy 5
- Compatible with NanoEdgeAIStudio solution to enable AI-based applications
- On-board battery status monitor
- Compatible with STBLESensor app (Android and iOS) to enable AI library control and monitoring, settings by PnP-Like protocol messages, firmware update via fast FUOTA, and bridging data to the Azure IoT central PnP cloud dashboard
- Based on accelerometer data up to 6 kHz bandwitdh
- NanoEdge AI libraries generated to run in the STM32WB module. Anomaly detection model storable in the external NOR flash memory
- Firmware modular example based on the embedded Light object-oriented fraMework enables code reusability at application level
- Utilities: datalog in binary format (coming from FP-SNS-DATAPRO1), python scripts and batch files to launch data acquisition, plot data and convert it to NanoEdgeAI format
- AzureRTOS: ThreadX, USBX
- Free, user-friendly license terms

Description

FP-AI-PDMWBSOC2 is an STM32Cube function pack for the STEVAL-PROTEUS1, able to get motion sensor data, process them to make anomaly detection, classification and extrapolation, and send the results to the STBLESensor mobile app, a PC terminal console and on Azure IoT central dashboard.

The function pack helps to explore the implementation and development of a predictive maintenance application that embeds the NanoEdge AI library middleware, capable to provide an AI-based solution (the NanoEdge AI libraries are generated using NanoEdgeAIStudio).

Using the DATAPRO1 binary file, the raw data can be extracted from the sensors inside the STEVAL-PROTEUS1 board and provided to the NanoEdgeAIStudio software to extract machine learning libraries anomaly detection, classification and extrapolation.

These NanoEdge AI libraries, customized and built on the classified set of data, can be easily updated inside the framework architecture proposed, facilitating the early detection, classification and severity estimation of potential failure within the equipment.

FP-AI-PDMWBSOC2 implements two different HMI communication tools at user level: a wired interactive CLI (USB CDC) to configure the node and manage the learning and inferencing phases, and the STBLESensor app with dedicated pages to provide the same functionalities. The STBLESensor mobile app works also as a bridge to display data on Azure IoT Central dashboard.

Product summary	
STM32Cube function pack for STEVAL-PROTEUS1 for AI anomaly detection and classification based on AzureRTOS	FP-AI-PDMWBSOC2
STM32Cube Function Pack for STEVALPROTEUS1 Sensor Datalog and File Transfer over BLE and USB	FP-SNS-DATAPRO1
Industrial sensor evaluation kit for condition monitoring based on the 2.4 GHz STM32WB5MMG module	STEVAL-PROTEUS1
BLE sensor application for Android and iOS	STBLESensor
Automated Machine Learning (ML) tool for STM32 developers	NanoEdgeAIStudio

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Product summary	
Applications	Condition Monitoring/ Predictive Maintenance
	IoT for Smart Industry

To start/stop the learning, detecting and classifying phases, an additional control, indicated by LEDs, can be performed by just pressing the user button.

The NanoEdge libraries functionalities are based on a set of application-level modules (Sensor Manager, Digital Processing Unit, EM Data), useful to reuse and easily extendable to build other customized applications.

1 Detailed description

1.1 What can you do with STM32Cube function packs?

STM32Cube function packs leverage the modularity and interoperability of STM32 Nucleo and X-NUCLEO boards together with STM32Cube and X-CUBE software to create function examples for some of the most common use cases of different application technologies.

These software function packs are designed to exploit the underlying STM32 ODE hardware and software components as much as possible to best satisfy the requirements of final user applications.

Moreover, function packs may include additional libraries and frameworks that are not present in the original X-CUBE packages, thus enabling new functionalities allowing real and usable system for developers.

1.2 What is STM32Cube?

STM32Cube is a combination of a full set of PC software tools and embedded software blocks running on STM32 microcontrollers and microprocessors:

- STM32CubeMX configuration tool for any STM32 device; it generates initialization C code for Cortex-M cores and the Linux device tree source for Cortex-A cores
- STM32CubeIDE integrated development environment based on open-source solutions like Eclipse or the GNU C/C++ toolchain, including compilation reporting features and advanced debug features
- STM32CubeProgrammer programming tool that provides an easy-to-use and efficient environment for reading, writing and verifying devices and external memories via a wide variety of available communication media (JTAG, SWD, UART, USB DFU, I2C, SPI, CAN, etc.)
- STM32CubeMonitor family of tools (STM32CubeMonRF, STM32CubeMonUCPD, STM32CubeMonPwr) to help developers customize their applications in real-time
- STM32Cube MCU and MPU packages specific to each STM32 series with drivers (HAL, low-layer, etc.), middleware, and lots of example code used in a wide variety of real-world use cases
- STM32Cube expansion packages for application-oriented solutions.

1.3 How does this function pack complement STM32Cube?

This software is based on the STM32CubeHAL. It extends STM32Cube by providing support for the STEVAL-PROTEUS1 evaluation kit to develop specific industrial predictive maintenance applications for early detection of warning signs of potential failure.

The package is mainly based on the following mandatory key elements:

- AzureRTOS: ThreadX, a small but powerful real-time operating system for embedded systems, and USBX, USB Host and USB Device embedded stack.

- The eLooM middleware to implement the object-oriented methodology for data management and processing with the AI library, easy to use at application level, which integrates four reusable software modules:

    - The Sensor Manager component retrieves sensor data and sets the sensor parameters. It is implemented as an acquisition engine that:

        ◦ Controls multiple task accesses to the sensor bus
        ◦ Defines interfaces to avoid implementation dependencies
        ◦ Dispatches events to notify when a certain amount of data is available

    - The Digital Processing Unit (DPU) component provides a set of processing blocks, which can be chained together, to create complex processing functions that use data stream coming from sensor manager. Available processing modules include:

        ◦ Anomaly detection (AD)
        ◦ N-Class classification (NCC)
        ◦ Extrapolation (E)

    - The EMData component defines a common data model among eLooM framework aligned to the standards used in data science tools. Around this data format, the component provides also some util classes and interfaces to address data driven use-cases.

Further details are available in the "Documentation" folder of the function pack and in the "Doc" folder of each firmware module.

Revision history

Table 1. Document revision history

Date	Revision	Changes
20-Jun-2023	1	Initial release.
28-Aug-2024	2	Updated Product summary table, Section Features, Section Description and Section 1.3: How does this function pack complement STM32Cube?.

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