Getting started with MotionAT active time library in X-CUBE-MEMS1 expansion for STM32Cube

Introduction

The MotionAT middleware library is part of the X-CUBE-MEMS1 software and runs on STM32. It combines results from activity recognition for wrist, motion intensity detection and pedometer for wrist algorithms. It also provides real-time information about the number of active seconds (that is how long the user was active with the wearable device as a smart watch).

This library is intended to work with ST MEMS only.

The algorithm is provided in static library format and is designed to be used on STM32 microcontrollers based on the ARM® Cortex®-M3, ARM® Cortex®-M33, ARM® Cortex®-M4 or ARM® Cortex®-M7 architecture.

It is built on top of STM32Cube software technology to ease portability across different STM32 microcontrollers.

The software comes with sample implementation running on an X-NUCLEO-IKS01A3 or X-NUCLEO-IKS4A1 expansion board on a NUCLEO-F401RE, NUCLEO-L152RE or NUCLEO-U575ZI-Q development board.

1 Acronyms and abbreviations

Table 1. List of acronyms

Acronym	Description
API	Application programming interface
BSP	Board support package
GUI	Graphical user interface
HAL	Hardware abstraction layer
IDE	Integrated development environment

2 MotionAT middleware library in X-CUBE-MEMS1 software expansion for STM32Cube

2.1 MotionAT overview

The MotionAT library expands the functionality of the X-CUBE-MEMS1 software.

The library acquires data from the accelerometer and provides information about the number of active seconds (how long the user was active) with the wearable device.

The library is designed for ST MEMS only. Functionality and performance when using other MEMS sensors are not analyzed and can be significantly different from what described in the document.

A sample implementation is available for X-NUCLEO-IKS01A3 or X-NUCLEO-IKS4A1 expansion boards, mounted on a NUCLEO-F401RE, NUCLEO-L152RE or NUCLEO-U575ZI-Q development board.

2.2 MotionAT library

Technical information fully describing the functions and parameters of the MotionAT APIs can be found in the MotionAT_Package.chm compiled HTML file located in the Documentation folder.

2.2.1 MotionAT library description

The MotionAT active time library manages the data acquired from the accelerometer; it features:

- Possibility of detecting the number of active seconds
- Recognition based on accelerometer data only
- Required accelerometer data sampling frequency of 50 Hz
- Measurement based on the accelerometer data only
- 16.5 Kbyte of code memory and 5.6 Kbyte of data memory usage
- Resources requirements:
  - Cortex®-M3: 21.8 KB of code and 5.5 KB of data memory
  - Cortex®-M33: 20.9 KB of code and 5.5 KB of data memory
  - Cortex®-M4: 23.0 KB of code and 5.5 KB of data memory
  - Cortex®-M7: 22.9 KB of code and 5.5 KB of data memory
- Available for ARM® Cortex®-M3, ARM® Cortex®-M33, ARM® Cortex®-M4, and ARM® Cortex®-M7 architectures

2.2.2 MotionAT APIs

The MotionAT library APIs are:

- `uint8_t MotionAT_GetLibVersion(char *version)`
  - retrieves the library version
  - `*version` is a pointer to an array of 35 characters
  - returns the number of characters in the version string
- `void MotionAT_Initialize(void)`
  - performs MotionAT library initialization and setup of the internal mechanism including the dynamic memory allocation
  - the CRC module in STM32 microcontroller (in RCC peripheral clock enable register) has to be enabled before using the library

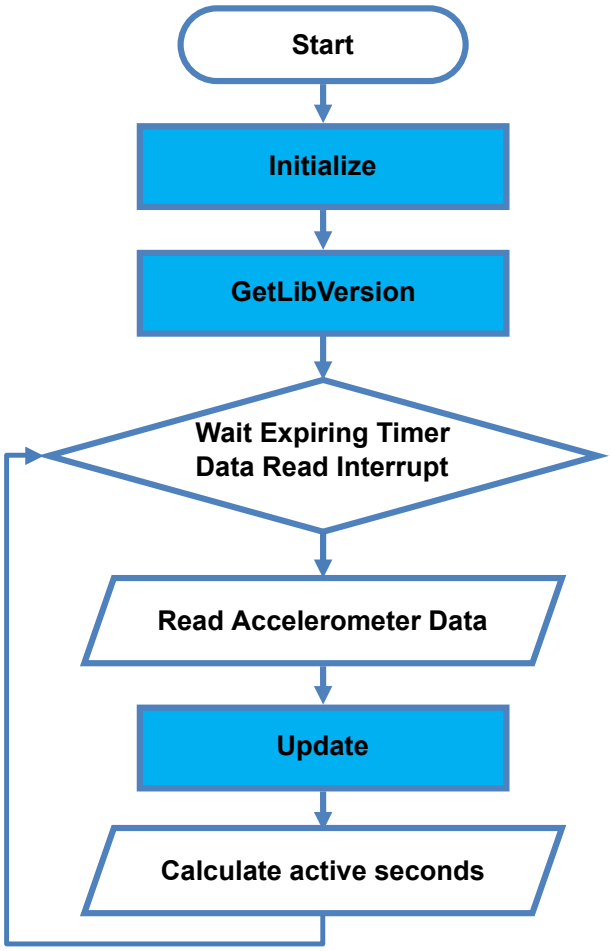
Note: This function must be called before using the active time library.

- `void MotionAT_Deinitialize(void)`
  - performs MotionAT library deinitialization including the dynamic memory deallocation

- `void MotionAT_Update(MAT_input_t *data_in, MAT_output_t *data_out)`
  - executes active time algorithm
  - `*data_in` parameter is a pointer to a structure with input data
  - the parameters for the structure type `MAT_input_t` are:
    - `acc_x` is the accelerometer sensor value in X axis in g
    - `acc_y` is the accelerometer sensor value in Y axis in g
    - `acc_z` is the accelerometer sensor value in Z axis in g
  - `*data_out` parameter is a pointer to a structure with output data
  - the parameter for the structure type `MAT_output_t` is:
    - `active` equal to 1 if the user was active during the last algorithm run, otherwise it is equal to 0

2.2.3 API flow chart

Figure 1. MotionAT API logic sequence



2.2.4 Demo code

```
[…]
#define VERSION_STR_LENG        35
[…]

/*** Initialization ***/
char lib_version[VERSION_STR_LENG];

/* Active Time API initialization function */
MotionAT_Initialize();

/* OPTIONAL */
/* Get library version */
  MotionAT_GetLibVersion(lib_version);

[…]

/*** Using Active Time algorithm ***/
Timer_OR_DataRate_Interrupt_Handler()
{
  MAT_input_t MAT_data_in;
  MAT_output_t MAT_data_out;

  /* Get acceleration X/Y/Z in g */
  MEMS_Read_AccValue(&MAT_data_in.acc_x, &MAT_data_in.acc_y, &MAT_data_in.acc_z);

  /* Run Active Time algorithm */
  MotionAT_Update(&MAT_data_in, &MAT_data_out);

  /* Count active seconds */
  /* 1/50Hz = 0.02s per 1 algorithm run */
  active_seconds += MAT_data_out.active * 0.02f;

}
```

2.2.5 Algorithm performance

The active time algorithm only uses data from the accelerometer and runs at a low frequency (50 Hz) to reduce power consumption.

It detects and provides real-time information about the number of active seconds (how long the user was active with his wearable device).

Table 2. Cortex-M4 and Cortex-M3: elapsed time (µs) algorithm

Cortex-M4 STM32F401RE at 84 MHz			Cortex-M3 STM32L152RE at 32 MHz		
Min	Avg	Max	Min	Avg	Max
38	55	619	302	520	6912

Table 3. Cortex-M33 and Cortex-M7: elapsed time (µs) algorithm

Cortex-M33 STM32U575ZI-Q at 160 MHz			Cortex-M7 STM32F767ZI at 96 MHz		
Min	Avg	Max	Min	Avg	Max
58	67	361	289	323	1622

2.3 Sample application

The MotionAT middleware can be easily manipulated to build user applications; a sample application is provided in the Application folder.

It is designed to run on a NUCLEO-F401RE, NUCLEO-L152RE, or NUCLEO-U575ZI-Q development board connected to an or X-NUCLEO-IKS01A3 or X-NUCLEO-IKS4A1 expansion board.

The application recognizes the active seconds in real-time. The data can be displayed through a GUI.

The USB cable connection is required to monitor real-time data. The board is powered by the PC via USB connection.

This allows the user to display whether the user was active during last single algorithm run, the amount of active seconds, accelerometer data, time stamp and eventually other sensor data, in real-time, using the MEMS-Studio GUI application.

2.4 MEMS-Studio application

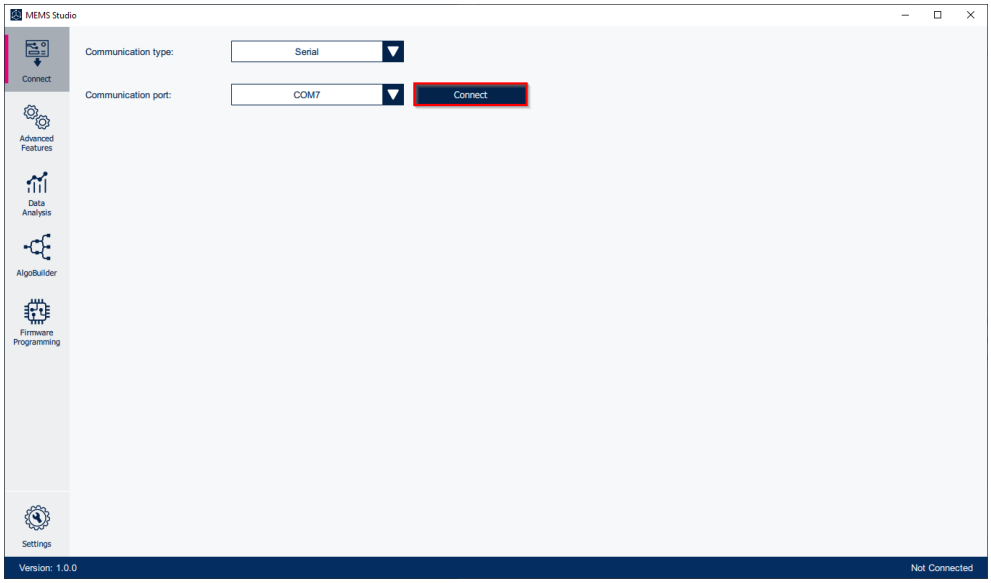
The sample application uses the MEMS-Studio GUI application, which can be downloaded from www.st.com.

Step 1. Ensure that the necessary drivers are installed and the STM32 Nucleo board with appropriate expansion board is connected to the PC.

Step 2. Launch the MEMS-Studio application to open the main application window.

If an STM32 Nucleo board with supported firmware is connected to the PC, the appropriate COM port is authomatically detected. Press [**Connect**] button to open this port.

Figure 2. MEMS-studio connect



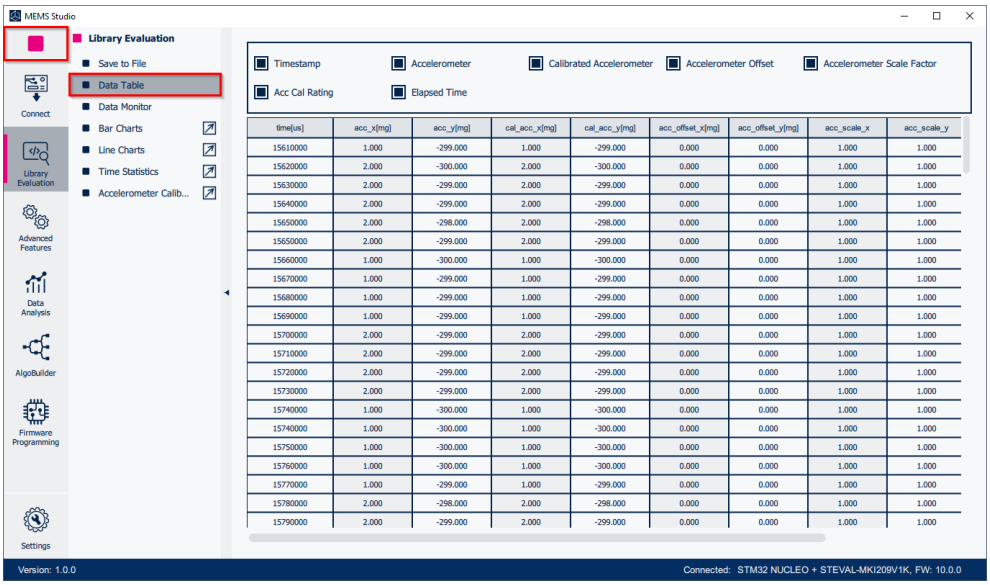
Step 3. When connected to STM32 Nucleo board with supported firmware [**Library Evaluation**] tab is opened. To start and stop data streaming toggle the appropriate start / stop button on the outer vertical tool bar.

Figure 3. Start

Figure 4. Stop

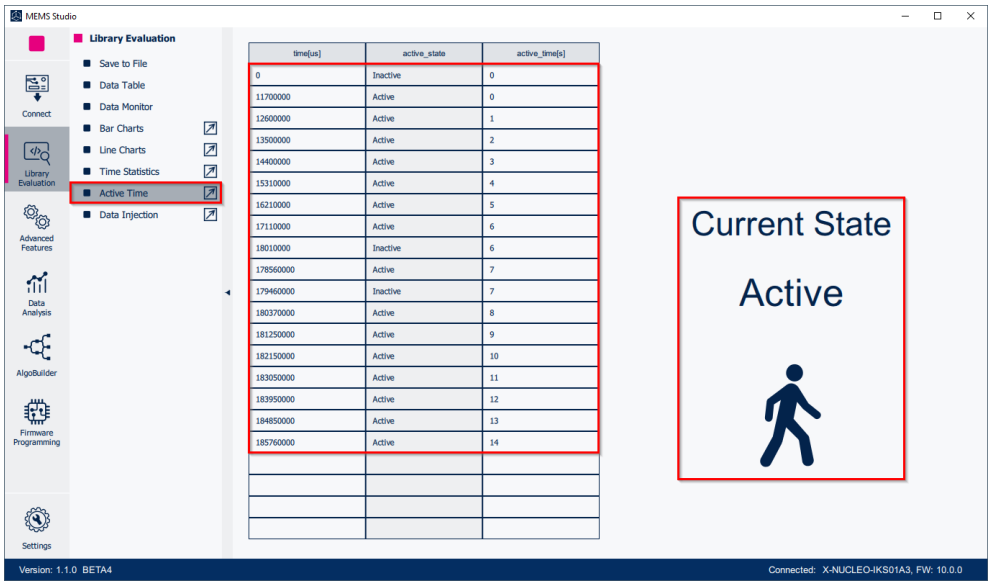
The data coming from the connected sensor can be viewed selecting the [**Data Table**] tab on the inner vertical tool bar.

Figure 5. MEMS-Studio - Library evaluation - Data table



Step 4. Select the [**Active Time**] tab on the inner vertical tool bar to open the dedicated application status view.

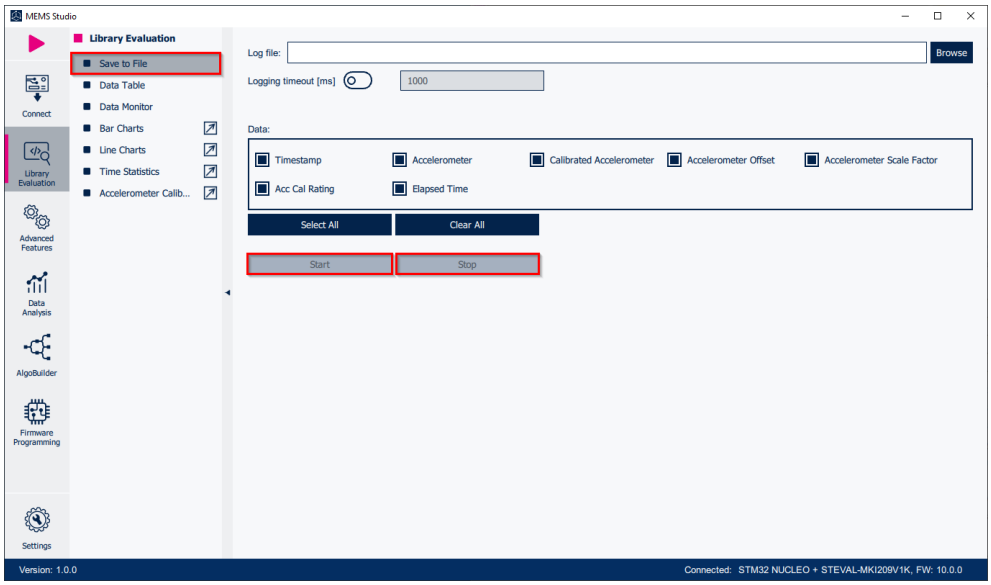
Figure 6. MEMS-Studio - Library Evaluation - Active Time



Step 5. Select the [**Save to File**] tab on the inner vertical tool bar to open the data logging configuration window.

You can select which sensor and activity data to save to log files. You can start or stop saving by clicking on the corresponding [**Start/Stop**] button.

Figure 7. MEMS-Studio - Library Evaluation - Save to File



3 References

All of the following resources are freely available on www.st.com.

1. UM1859: Getting started with the X-CUBE-MEMS1 motion MEMS and environmental sensor software expansion for STM32Cube
2. UM1724: STM32 Nucleo-64 boards (MB1136)
3. UM3233: Getting started with MEMS-Studio

Revision history

Table 4. **Document revision history**

Date	Version	Changes
31-Jan-2018	1	Initial release.
21-Mar-2018	2	Updated Introduction and Section 2.1 MotionAT overview.
14-Feb-2019	3	Updated Table 2. Elapsed time (µs) algorithm and Figure 2. STM32 Nucleo: LEDs, button, jumper. Added X-NUCLEO-IKS01A3 expansion board compatibility information.
24-May-2024	4	Updated Introduction, Section 2.1: MotionAT overview, Section 2.2.1: MotionAT library description, Section 2.2.2: MotionAT APIs, Section 2.2.4: Demo code, Section 2.2.5: Algorithm performance, Section 2.3: Sample application. Replaced Unicleo-GUI application with Section 2.4: MEMS-Studio application.

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