Sensor solutions for human machine interface

- **Smart motion sensors**
- **Inertial measurement unit for TWS applications**
- **Pison’s neural gesture control**
- **Goertek’s production ready smart ring**

Key attributes of MEMS sensors

Accurate

Sensors providing a **correct set of data**

Open

Sensors configured to **your needs**

Smart

Sensors able to **process data**

Meaningful data provided in an optimal way

Human centered

Sustainable

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Bringing intelligence at the edge

Embedded features

Pre programmed embedded features and finite state machine (FSM) for motion tracking

- **Best-in-class low-power** sensors
- Advanced pedometer, significant motion and tilt detection, free-fall, wake-up, 6D / 4D orientation, click and double click
- **Sensor fusion** low power

MLC — Machine learning core

In-sensor classification engine based on decision tree logic

- **Extremely low-power** sensors
- **Increased accuracy** with a better context detectability
- **Offloading** of the main processor, improving system efficiency

ISPU — Intelligent sensor processing unit

Highly specialized DSP for machine learning and processing

- **Ultra-low power** consumption at **system level**, thanks to **optimized data transfer**
- High-processing capability with **AI-enabled programmable core**
- Comprehensive **ecosystem**

Sensor hub feature, enabling connection of external standard sensors

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Low power sensor fusion for always-on applications

Plug & play solution for edge processing

6x game rotation vector (accelerometer + gyroscope)

High performance and **high-accuracy**

Ultra-low power operation
50% power reduction vs. external MCU(3) processing

Static accuracy(1): 0.5, 1.5, 1.5 deg
Low dynamic accuracy(1): 0.7, 0.5, 0.5 deg
Calibration time(2):0.8 s
Orientation stabilization time: 0.7 s
Extra power: 30 µA @ 120 MHz

(1) Heading (5min), pitch and roll
(2) Time required to reach steady state
(3) Same sensor fusion software library running on STM32L476RG cortex M4 @ 65 uA (120Hz ODR)

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Adaptive self configuration (ASC)

From “Always-on” to “Always-aware”

The device automatically **reconfigure itself**, based on the actual context, maximizing the **system efficiency**.

MLC and FSM detect the context without the need of additional data processing

ASC allows to independently configure gyroscope and accelerometer

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In-sensor processing with MLC and FSM

Machine learning core

Data acquisition campaign

Engine matches data patterns with user-defined classes

Understand scenarios based on training data

Finite state machine

Series of state parameters with defined transitions

Recognize gestures

Multiple FSM programs in parallel

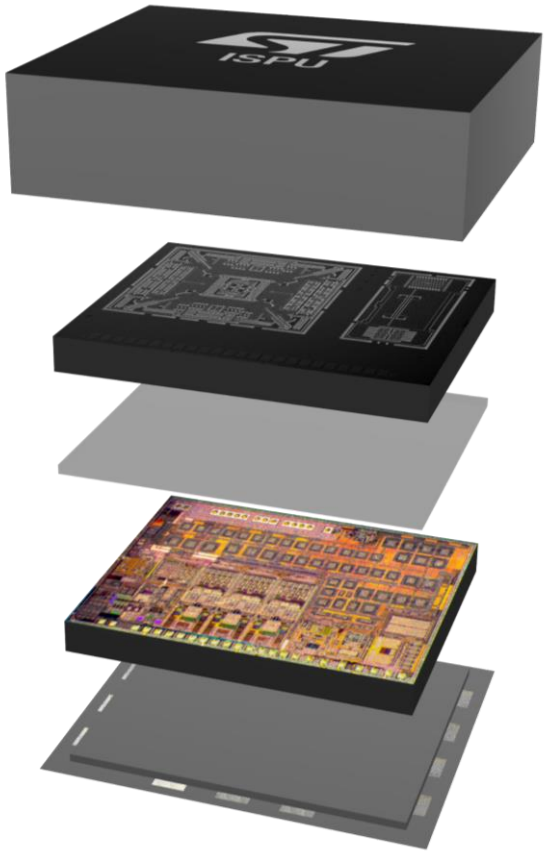
Activity tracking

Input	Labeled sensor data with features
Logic	Machine learning based logic
Output	Pattern classification using a decision tree

Gesture recognition

Input	Sensor samples data
Logic	Event-/trigger-based logic using thresholds/timers
Output	Event detection using commands and conditions

Intelligent sensor processing unit



The ISPU is a fully integrated digital signal processor (DSP) that is optimized for sensor data processing and can run even complex AI algorithms

Ultralow power consumption at system level, thanks to optimized data transfer

High processing capability with AI-enabled programmable core (machine learning and neural network)

Easily programmable in C language or with commercial and open-source AI models

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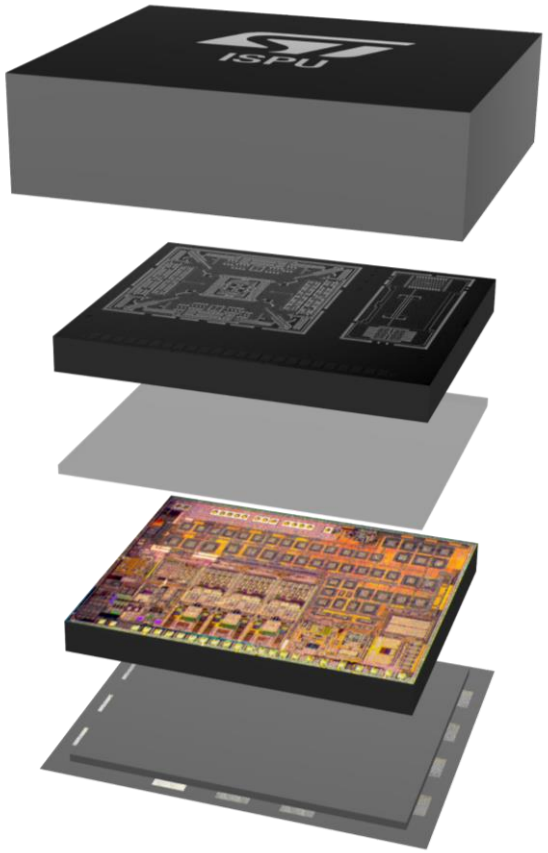
Intelligent sensor processing unit



The ISPU is a fully integrated digital signal processor (DSP) that is optimized for sensor data processing and can run even complex AI algorithms

Small area: enhanced 32-bit RISC Harvard architecture

RAM based
40 KB (program + execution)

Full precision
Floating-point unit

Binary neural network convolution accelerator

Fast interrupt response
4 cycles vs 15 (Cortex®)

Frequency/output data rate
5 MHz / 3.33 kHz – 10 MHz / 6.66 kHz

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IMU for TWS
LSM6DSV16BX

LSM6DSV16BX is a unique IMU: 6x IMU plus **wide bandwidth accelerometer**, embedded features and analog front end input for user interface (Qvar)

Compatible with **I³C interface** and **audio interfaces (TDM, I²S)**

Sensor fusion low power (**SFLP**), finite state machine (**FSM**) and machine learning core (**MLC**), adaptive self configuration (**ASC**)

Device and FSM / MLC **configurations available on GitHub**

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Wide-band accelerometer

Ready to differentiate the user voice from the environment?

Voice propagates through the skull bones and can be captured by an accelerometer. The signal is **immune from background noise** and can be used for **speech enhancement** applications

Wide band accelerometer is embedded in LSM6DSV16BX IMU to detect the voice through bone conduction in a frequency range that **exceeds 1KHz**

Compatible with **TDM and I^2S audio interface** to ensure proper data transmission for audio applications (8 kHz or 16 kHz)

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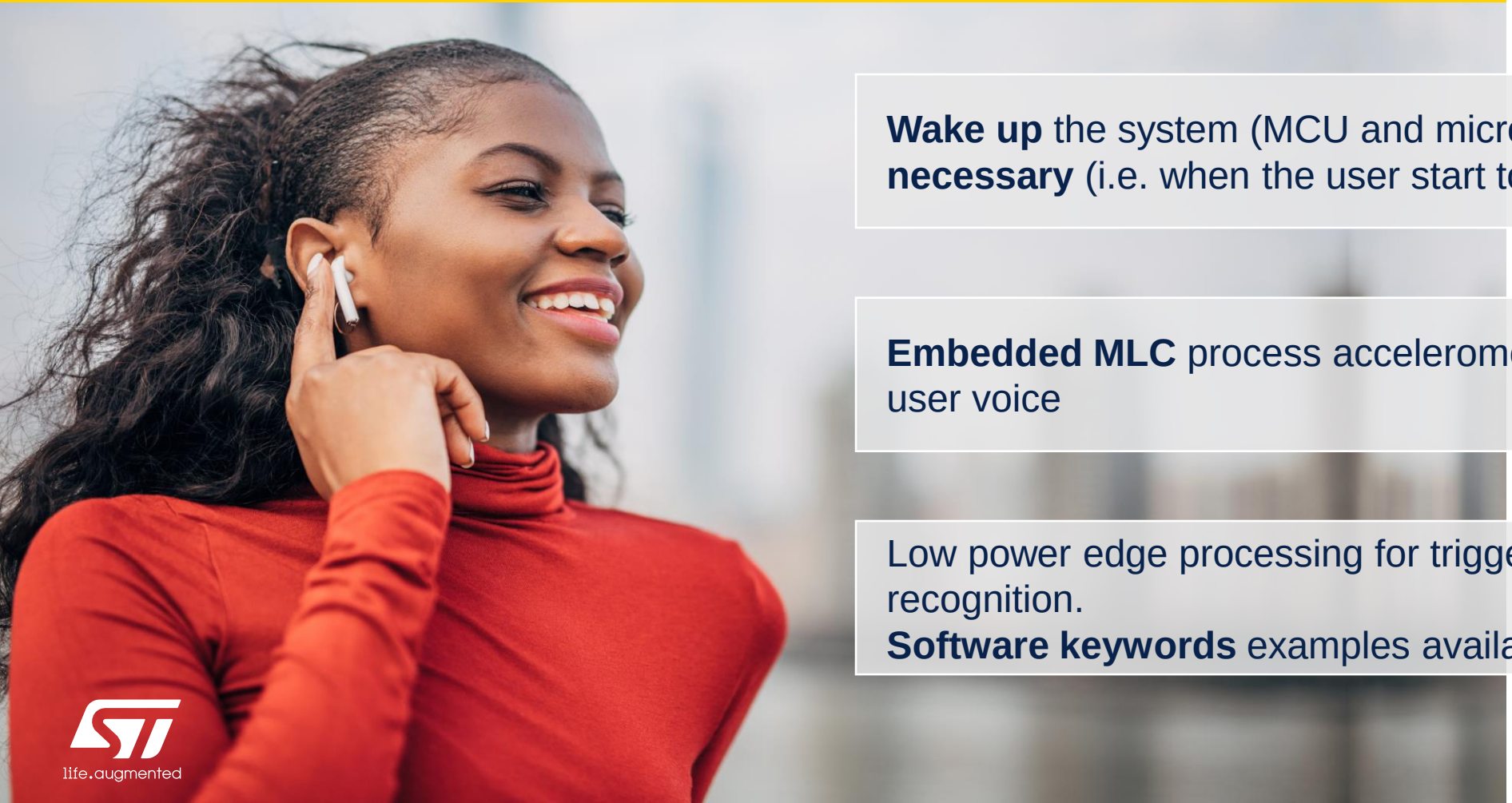
Voice activity detection (VAD)

LSM6DSV16BX detect voice using AI



Wake up the system (MCU and microphones) only when **necessary** (i.e. when the user start to talk)

Embedded MLC process accelerometer signal to detect the user voice

Low power edge processing for triggering software keyword recognition.
Software keywords examples available

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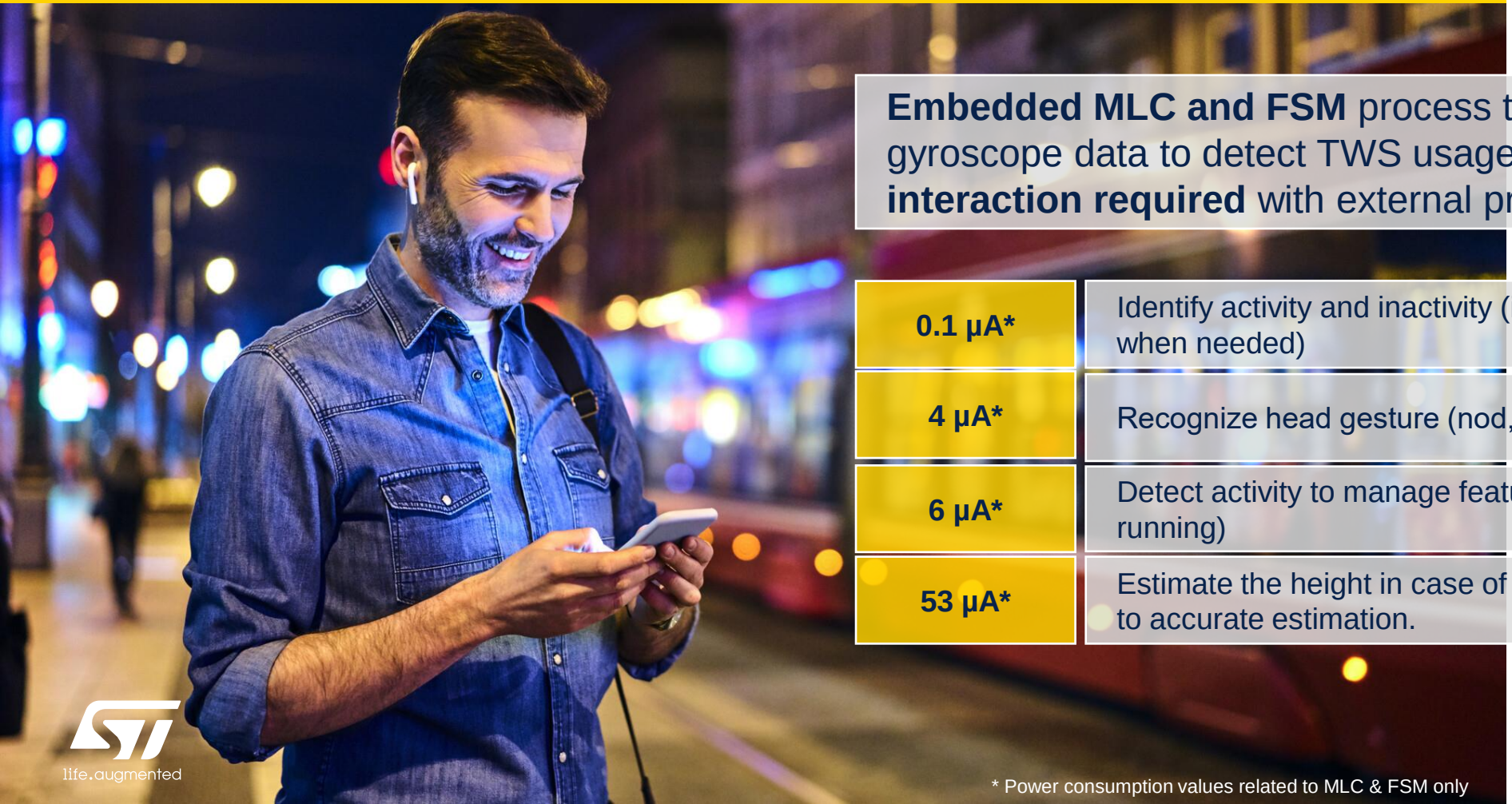
Context awareness detection in TWS applications

Adding intelligence in the edge with MLC and FSM



Embedded MLC and FSM process the accelerometer and gyroscope data to detect TWS usage conditions with **no interaction required** with external processor

0.1 µA*	Identify activity and inactivity (i.e., wake up the system only when needed)
4 µA*	Recognize head gesture (nod, shake, …)
6 µA*	Detect activity to manage features (i.e. noise cancelling when running)
53 µA*	Estimate the height in case of TWS drop, from threshold (1 µA) to accurate estimation.

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* Power consumption values related to MLC & FSM only

Neural gesture control

The next human machine interface

Full solution from ST in partnership with Pison

Pison pioneered the use of electroneurography (ENG) to capture arm, hand, and finger movements as a natural-language human machine interface

STMicroelectronics developed the STENG01AX sensor specifically designed to capture ENG signals

Production ready smart ring

Interface through motion

Goertek is a vertically integrated company focusing on components and products manufacturing for wearable, viewable and hearable among many applications

Smart gestures implemented in STMicroelectronics' latest IMU LSM6DSV16X with machine learning core:

- finger pinch
- slide left and right
- wrist flip left and right