tinyML® Summit

Enabling Ultra-low Power Machine Learning at the Edge

Products and applications enabled by tinyML

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Personal Computing devices use-case and applications enabled by smart sensors

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STMicroelectronics

“Hybrid work is here to stay, and it’s the greatest shift in the way people work in our lifetimes”.

Enrique Lores,
President & CEO
HP

+

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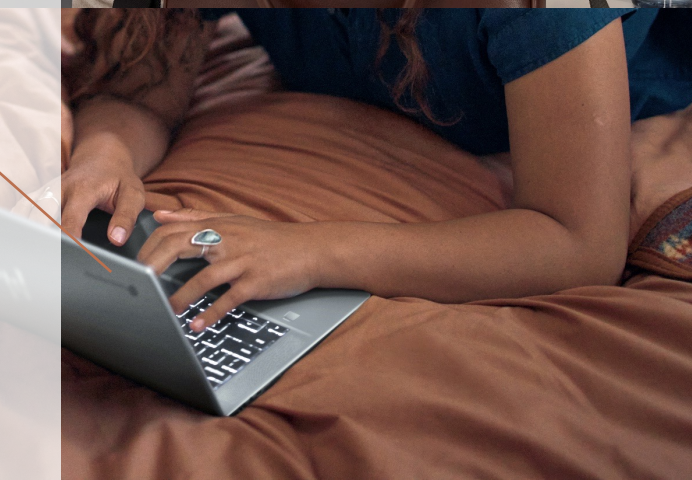
Your PC intelligently knows when you’re on the go and optimizes your battery life

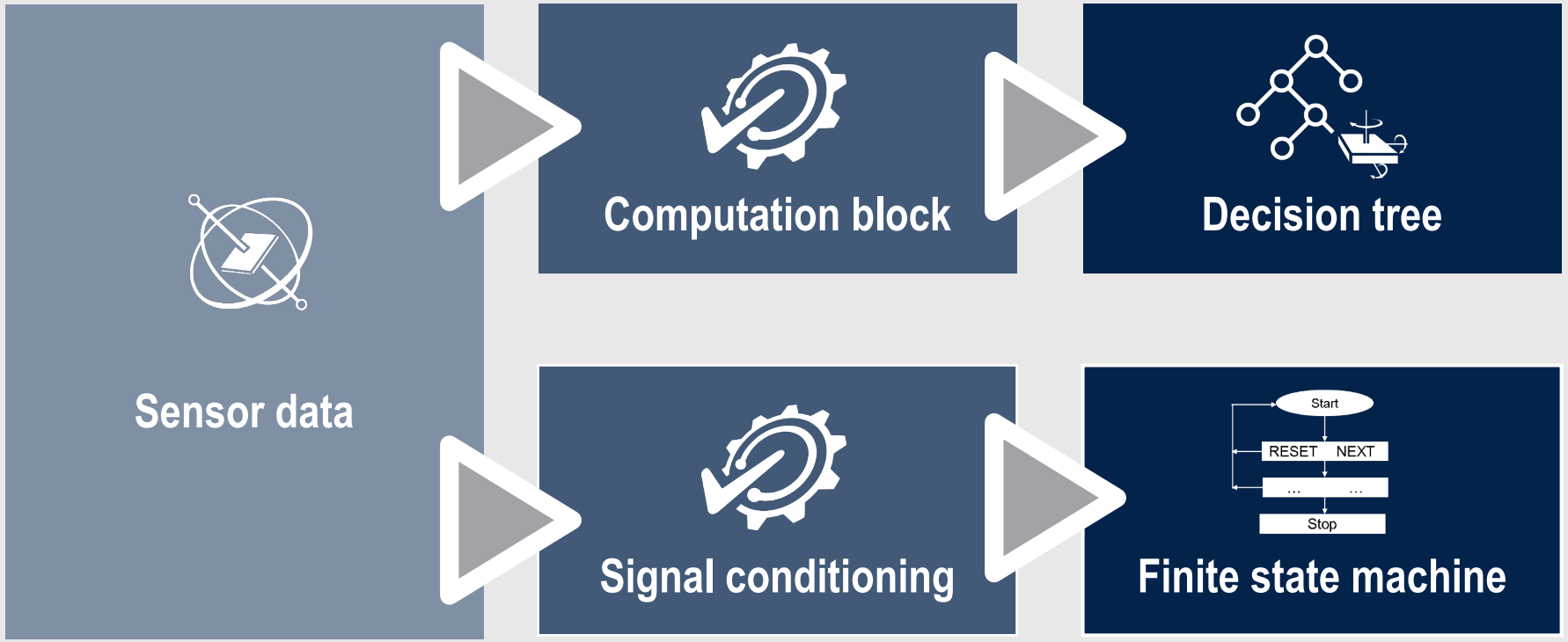
Your PC knows you’ve taken it out of your bag and begins setting everything up for you so you can start work faster

Intelligently lowers your device temperature when you’re using your PC on a soft surface



Machine Learning Core

Reconfigurable processing unit that performs a decision tree logic



Extreme power efficiency with smart sensors

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

Sensor hub feature, enabling connection of external standard sensors, bringing **intelligence at the edge**

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Computation Block - Features

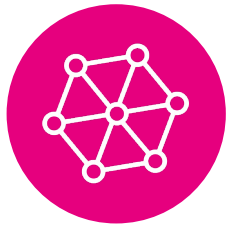
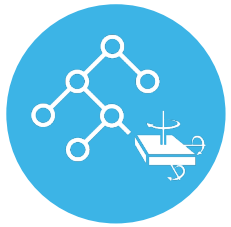
Features: statistical parameters calculated from Input data / Filtered data

Feature Name	Feature Description
MEAN	Computes the average of the selected input in the defined time window $$Mean = \frac{1}{WL}\sum_{k=0}^{WL-1} I_k$$
VARIANCE	Computes the variance of the selected input in the defined time window $$Variance = \left[\left(\frac{\sum_{WL} i^2}{WL}\right) - \left(\frac{\sum_{WL} i}{WL}\right)^2\right]$$
ENERGY	Computes the energy of the selected input in the defined time window $$Energy = \sum_{k=0}^{WL} input^2$$
PEAK TO PEAK	Computes the maximum peak to peak value of the selected input in the defined time window
ZERO CROSSING	Computes the number of times the selected input crosses a selected threshold in the defined time window
POSITIVE ZERO CROSSING	Computes the number of times the selected input crosses a selected threshold in the defined time window. Only transitions with positive slope are considered.
NEGATIVE ZERO CROSSING	Computes the number of times the selected input crosses a selected threshold in the defined time window. Only transitions with negative slopes are considered.
PEAK DETECTOR	Counts the number of peaks (positive and negative) of the selected input in the defined time window
POSITIVE PEAK DETECTOR	Counts the number of positive peaks of the selected input in the defined time window
NEGATIVE PEAK DETECTOR	Counts the number of negative peaks of the selected input in the defined time window
MINIMUM	Minimal value of the selected input in the defined time window
MAXIMUM	Maximum value of the selected input in the defined time window

Machine Learning solutions in sensors: new developer model approach

Shorter development time and better accuracy with use of Machine Learning techniques (decision trees)

Machine Learning Core configuration | Operating mode

Capture data	Label data	Build decision tree	Embed decision tree	Process new data
				
• Accelerometer • Gyroscope • External sensors	• Filters • Features	• Classification • Results	• DT implementation	• Real time test

HOW

Unico-GUI

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HP motion AI

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HP use cases

In/Out bag detection (IOB)

The In/Out bag detection feature is designed to solve the laptop overheating problem by setting the system in hibernate when it is carried inside of a bag

Detect laptop carried In-Bag/Out-Bag classes

Enter hibernate when the laptop is carried in a bag

Laptop instant-on when taken out from a bag

Detect laptop taken out from the bag event

- Smart power state transition
- Avoid the laptop overheating
- Optimize the battery usage

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HP use cases

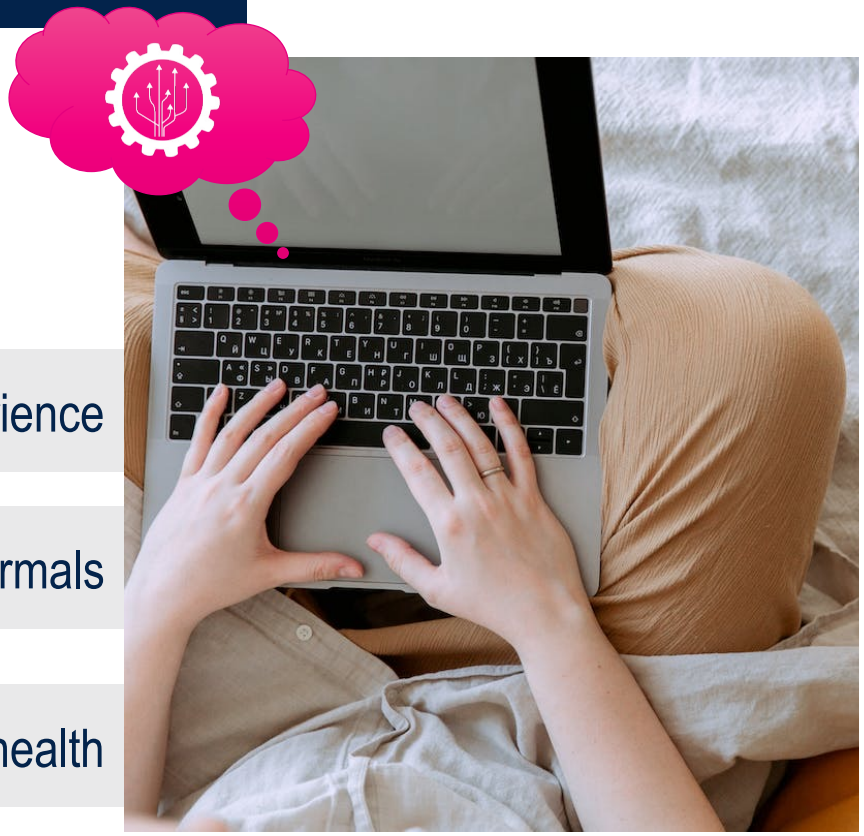
On-Table detection (OTD)

The on-table detection feature is used by the system to activate specific power policies affecting the system clocks, the fans speed and thermals based on the on-table or on-soft-surface output

Detect laptop used on-table or on-soft-surface classes

Optimize system power policies

- Enhance the user experience
- Manage thermals
- Safeguard the user's health



Data collection

Logging IOB / OTD data from HP laptops

Machine Learning Core configuration | Operating mode

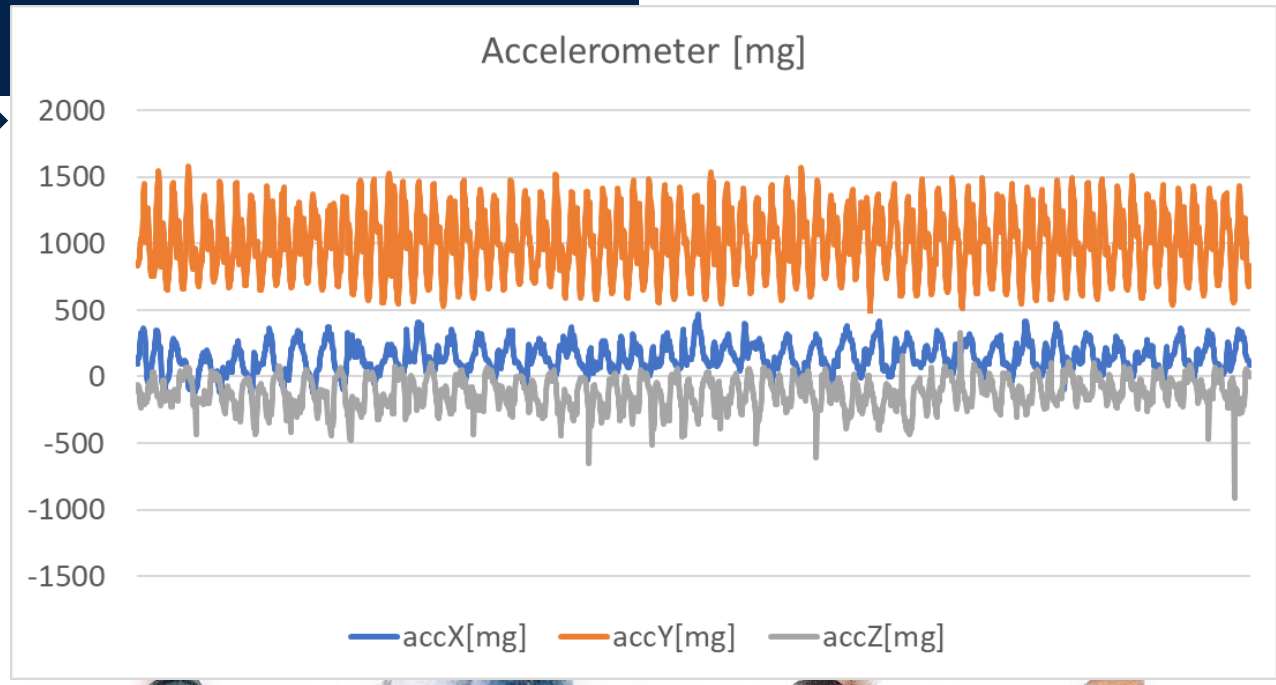
Capture data › Label data › Build decision tree › Embed decision tree › Process new data

HP defined the IOB / OTD user experience, and provided systems having the LSM6DSOX device

ST and HP defined the list of scenarios to be collected for implementing the required user experience

ST developed a specific application to simplify the data collection phase and the labeling

More than 50 ST+HP worldwide employees helped with data collection campaign and testing!



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AI model generation

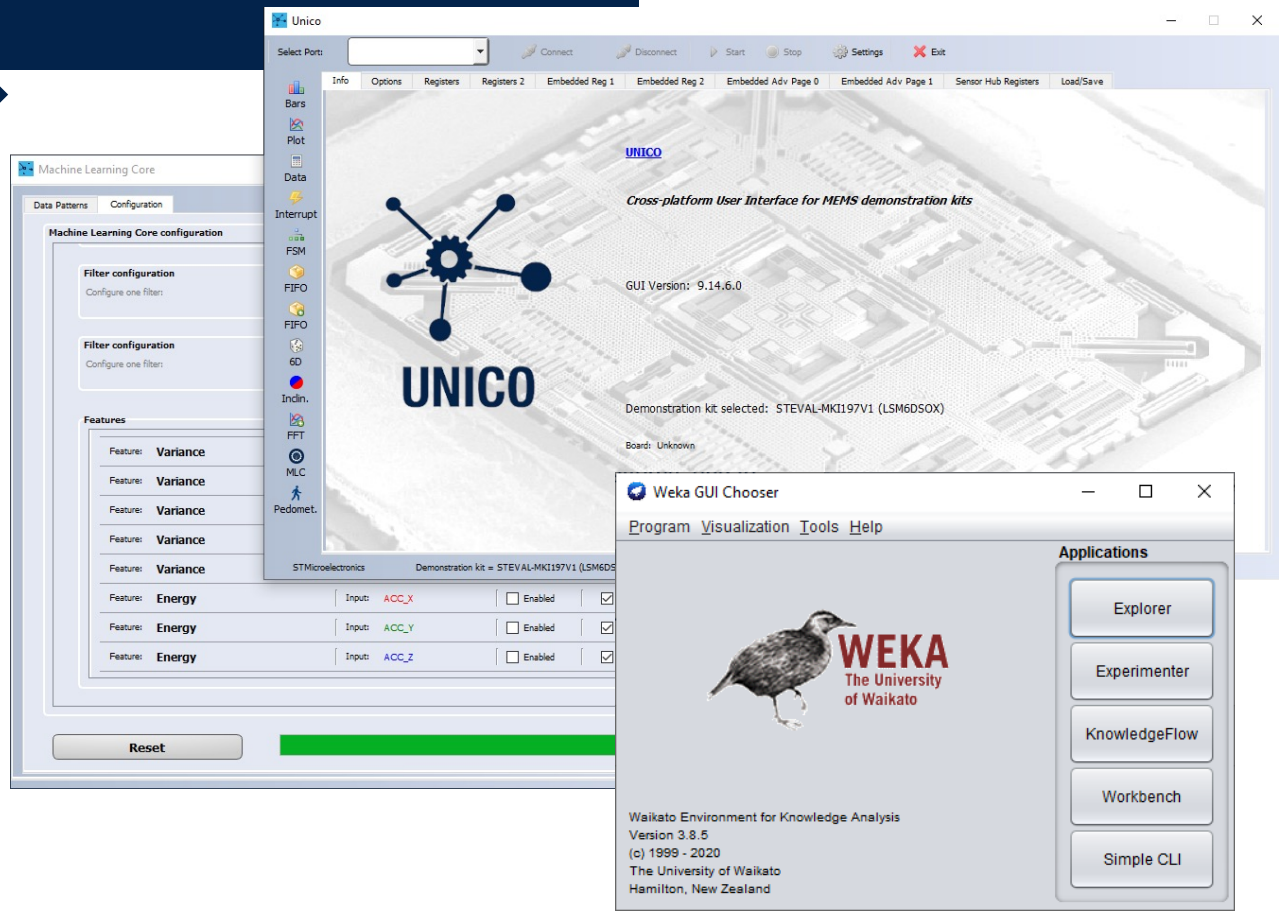
ST UNICO and WEKA tools

Machine Learning Core configuration | Operating mode

ST UNICO tool used to compute the features value related to the dataset

WEKA tool used to find which features better characterize the IOB / OTD motion patterns, and to build the decision tree

ST UNICO tool used to generate the LSM6DSOX device configuration running the built decision trees directly into the embedded Machine Learning Core



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Drivers preparation and validation

ST drivers running the IOB / OTD features

Machine Learning Core configuration | Operating mode

ST developed the drivers to be integrated in the HP final product, and a specific application suitable for the validation of the features

HP integrated the ST drivers and completed the validation

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Excellent user experience with tiny current consumption

Only 34 µA additional current consumption to run IOB and OTD with MLC

The MCU wakes up only when a new IOB or OTD output is detected

LSM6DSOX sensor	Current consumption
Accelerometer and gyroscope	550 µA
IOB and OTD features	**34 µA**
	Total: 584 µA

- **Energy saving**
- **Always-on features**
- **Enhanced user experience**

If implemented on the Application Processor, the computation current consumption for these features could be approximately 10 time more than above numbers.

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Our technology starts with You

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