Artificial intelligence solutions running on STM32
Product development new paradigm

From rule-based engineering to data-driven engineering

Standard programming
Handcrafted rules based on experience

- Requires digital signal processing skills
- Manual feature extraction?
- Need to rewrite if environment evolves

Machine learning
Rules learned from real-world data

- Generate code from real-world observations
- Automated feature extraction?
- Relearn from data if environment evolves
Distributed artificial intelligence approach

Leverage billions of devices at the edge!

Data Center Cloud
- Analytics, storage, compute

Edge nodes
- IoT gateways, micro datacenters

Edge things
- Ultra-low-power devices and sensors
- Real time, local processing

Thousands

Millions

100 billion
Artificial intelligence at the edge

Moving part of artificial intelligence closer to the data acquisition brings several benefits

- **Ultra-low latency**
  - Real-time applications

- **More reliability**

- **Security of data**
  - No sharing in the cloud

- **Privacy by design**
  - GDPR compliant

- **Sustainable on energy**
  - Low-power consumption

- **Better user experience**
160 billion machines just “want” to do a better job

The washer is not draining properly because a belt is showing signs of wear

HOME MAINTENANCE

The pump is about to break down due to a failure on a ball bearing

INDUSTRIAL MAINTENANCE

An unusual noise has been detected and recognized as a window break

SECURITY

Enterprise restaurant is full and your waiting time is currently estimated to 15mn

PEOPLE COUNTING
If only I had solutions to overcome AI design challenges.
This is where we come in.
There is an AI solution for every need

**COMPANY’S PROFILE**

- Embedded developers
  - No dataset available
  - No dedicated AI Team

- Team with AI expertise
  - Dataset available
  - AI Team

**USE CASES**

- Anomaly detection
- Classification
- Deep Learning

**USE CASES**

- NANOEDGE AI STUDIO
- NANOEDGE AI STUDIO
- STM32 Cube.AI
- STM32 Cube.AI

**COMPANY’S PROFILE**

- Embedded developers
  - No dataset available
  - No dedicated AI Team

- Team with AI expertise
  - Dataset available
  - AI Team

**USE CASES**

- NANOEDGE AI STUDIO
- NANOEDGE AI STUDIO
- STM32 Cube.AI
- STM32 Cube.AI
NanoEdge AI Studio, an automated ML design solution

For embedded developers

A unique solution thought from scratch

HOW DID WE DO IT?

We rewrote the algorithms, from the algebra, ML, and signal processing algorithms, so that they can LEARN and INFERENCE inside an MCU.

- Patented technology
- Designed for embedded developers
- Ultra memory efficient (Flash and RAM)
- Unsupervised learning in the device
- Superior security
- Small footprint, runs on any STM32
- Close to 100% accuracy and confidence
STM32Cube.AI helps you accelerate your embedded development

Easily evaluate, convert, and deploy machine learning and deep neural networks on STM32

An AI extension integrated with the STM32Cube MCU development environment to **optimize** and **tune** models, directly on target.

- Develop and train your model with major AI frameworks
  - TensorFlowLite
  - K
  - ONNX
  - PyTorch
- Best ML performance on STM32 (MLPerf™ Tiny benchmarks)
- Validate performance directly on target
- Small footprint, runs on any STM32
Making Edge AI accessible to all STM32 portfolio

NanoEdge AI Studio & STM32Cube.AI are both compatible with all STM32 series

<table>
<thead>
<tr>
<th>MPU</th>
<th>STM32F3</th>
<th>STM32G4</th>
<th>STM32F2</th>
<th>STM32F4</th>
<th>STM32F7</th>
<th>STM32H7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>245 CoreMark</td>
<td>569 CoreMark</td>
<td>Up to 398 CoreMark</td>
<td>Up to 608 CoreMark</td>
<td>1082 CoreMark</td>
<td>Up to 3224 CoreMark</td>
</tr>
<tr>
<td></td>
<td>72 MHz Cortex-M4</td>
<td>120 MHz Cortex-M3</td>
<td>210 MHz Cortex-M4</td>
<td>120 MHz Cortex-M4</td>
<td>216 MHz Cortex-M4</td>
<td>Up to 550 MHz Cortex-M4</td>
</tr>
<tr>
<td></td>
<td>Optimized for mixed-signal applications</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>High Perf MCUs</th>
<th>STM32F0</th>
<th>STM32G0</th>
<th>STM32F1</th>
<th>STM32F2</th>
<th>STM32F4</th>
<th>STM32F7</th>
<th>STM32H7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>106 CoreMark</td>
<td>142 CoreMark</td>
<td>177 CoreMark</td>
<td>Up to 398 CoreMark</td>
<td>Up to 608 CoreMark</td>
<td>1082 CoreMark</td>
<td>Up to 3224 CoreMark</td>
</tr>
<tr>
<td></td>
<td>48 MHz Cortex-M0</td>
<td>64 MHz Cortex-M0+</td>
<td>72 MHz Cortex-M3</td>
<td>120 MHz Cortex-M3</td>
<td>210 MHz Cortex-M4</td>
<td>216 MHz Cortex-M4</td>
<td>Up to 550 MHz Cortex-M4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mainstream MCUs</th>
<th>STM32L0</th>
<th>STM32L1</th>
<th>STM32L4</th>
<th>STM32L4+</th>
<th>STM32L5</th>
<th>STM32U5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>75 CoreMark</td>
<td>93 CoreMark</td>
<td>273 CoreMark</td>
<td>409 CoreMark</td>
<td>443 CoreMark</td>
<td>651 CoreMark</td>
</tr>
<tr>
<td></td>
<td>32 MHz Cortex-M0+</td>
<td>32 MHz Cortex-M3</td>
<td>80 MHz Cortex-M4</td>
<td>120 MHz Cortex-M4</td>
<td>110 MHz Cortex-M33</td>
<td>160 MHz Cortex-M33</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ultra-low Power MCUs</th>
<th>STM32L0</th>
<th>STM32L1</th>
<th>STM32L4</th>
<th>STM32L4+</th>
<th>STM32L5</th>
<th>STM32U5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>75 CoreMark</td>
<td>93 CoreMark</td>
<td>273 CoreMark</td>
<td>409 CoreMark</td>
<td>443 CoreMark</td>
<td>651 CoreMark</td>
</tr>
<tr>
<td></td>
<td>32 MHz Cortex-M0+</td>
<td>32 MHz Cortex-M3</td>
<td>80 MHz Cortex-M4</td>
<td>120 MHz Cortex-M4</td>
<td>110 MHz Cortex-M33</td>
<td>160 MHz Cortex-M33</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wireless MCUs</th>
<th>STM32WL</th>
<th>STM32WB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>162 CoreMark</td>
<td>216 CoreMark</td>
</tr>
<tr>
<td></td>
<td>48 MHz Cortex-M4</td>
<td>64 MHz Cortex-M4</td>
</tr>
<tr>
<td></td>
<td>48 MHz Cortex-M0+</td>
<td>32 MHz Cortex-M0+</td>
</tr>
</tbody>
</table>

STM32MP1
4158 CoreMark
Up to 800 MHz Cortex-M7
209 MHz Cortex-M0+
ST now offers the ultimate AI solution framework

Stay focused on your expertise, we bring you everything else

- **AI Design Services**
  - Proven methodology to accelerate ML innovation process
  - Partner ecosystem

- **AI Software and ecosystem**
  - NANOEDGE AI STUDIO
  - STM32Cube.AI
  - Function Packs

- **Hardware**

**Your industry Expertise**

- Lead with true innovation
- Improved time to market
- Optimize cost
- Minimize risks
ST now offers the ultimate AI solution framework

<table>
<thead>
<tr>
<th>Your Industry Expertise</th>
<th>AI Design Services</th>
<th>AI Software and ecosystem</th>
<th>Hardware</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Lead with true innovation</td>
<td>✓ Proven methodology to accelerate ML innovation process</td>
<td>✓ Best AI offering portfolio on the market</td>
<td>✓ Most comprehensive HW portfolio to address all projects and communication environment</td>
</tr>
<tr>
<td>✓ Improved time to market</td>
<td>✓ Delivered direct or through certified partner ecosystem</td>
<td>✓ Most comprehensive AI stack ranging from deep learning computer vision to self-learning anomaly detection.</td>
<td></td>
</tr>
<tr>
<td>✓ Optimize cost</td>
<td>✓ Direct R&amp;D assistance for all sprint projects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ Minimize risks</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Stay focused on your expertise, we bring you everything else.
Releasing your creativity

/STM32

@ST_World

community.st.com

www.st.com/STM32CubeAI

For more information, contact us at edge.ai@st.com
Our technology starts with You

Find out more at stm32ai.st.com/