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Enabling Ultra-low Power Machine Learning at the Edge

tinyML EMEA Technical Forum 2021 Proceedings

June 7 – 10, 2021

Virtual Event

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tinyML EMEA Technical Forum 2021
June 7-10, 2021

A TinyML Platform for On-Device Continual Learning with Quantized Latent Replays

Presented by: *Leonardo Ravaglia*, *Ph.D. student in Data Science and Computation*, University of Bologna, Italy

June 4, 2021

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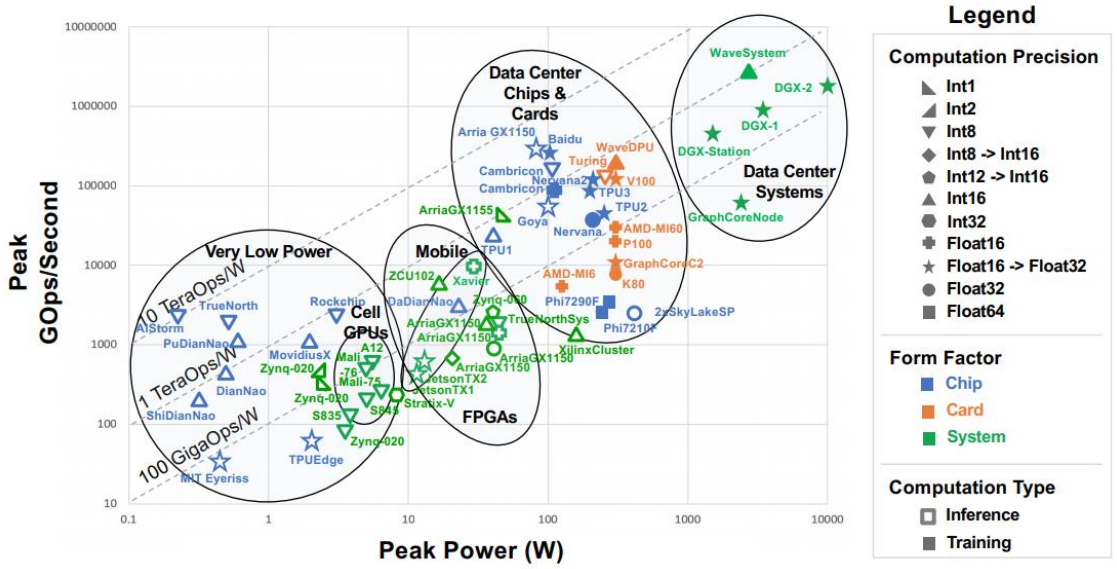
1. **DNN inference** capability has been already demonstrated, but the **training of DNN** models still relies on GPU-based machines.
2. Transfer Learning or incremental training lead to accuracy loss and **Catastrophic Forgetting**.

A way out of this limitations can be found in **Continual Learning** (CL) algorithms:

- **CL enables training** also on **TinyML** platforms, with very bounded memory and computational resources.



"Survey and benchmarking of machine learning accelerators", Reuther A. et al.

- **Continual Learning with Latent Replays** is our choice, since offers a solution compatible with embedded devices resources.

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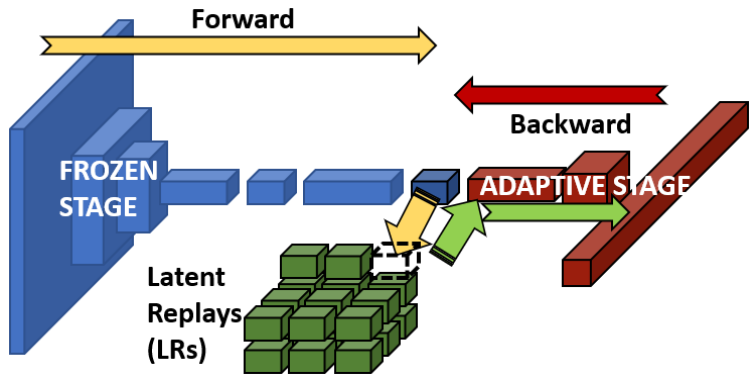
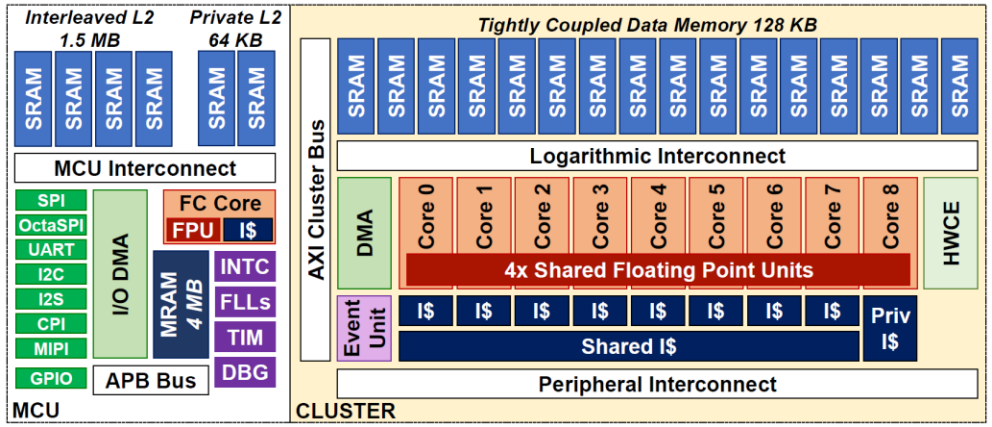


"Latent replay for real-time continual learning", Pellegrini et al.

Contributions

- We **extend the CL with LR algorithm** to work with 8-bit quantized frozen stage.
- We propose a set of CL primitives for forward and backward propagation of common layers: **convolution**, **depth-wise convolution** and **fully connected layers.**

- We fine-tune and optimize the **execution on VEGA**, a TinyML platform for Deep Learning based on **PULP**. We also introduce a **tiling scheme** to manage data movement for the CL primitives.
- We **compare the performance of our CL primitives on VEGA with that on other devices** that could in the future target on-chip at-edge learning (e.g. STM32 L4).



PULP paradigm

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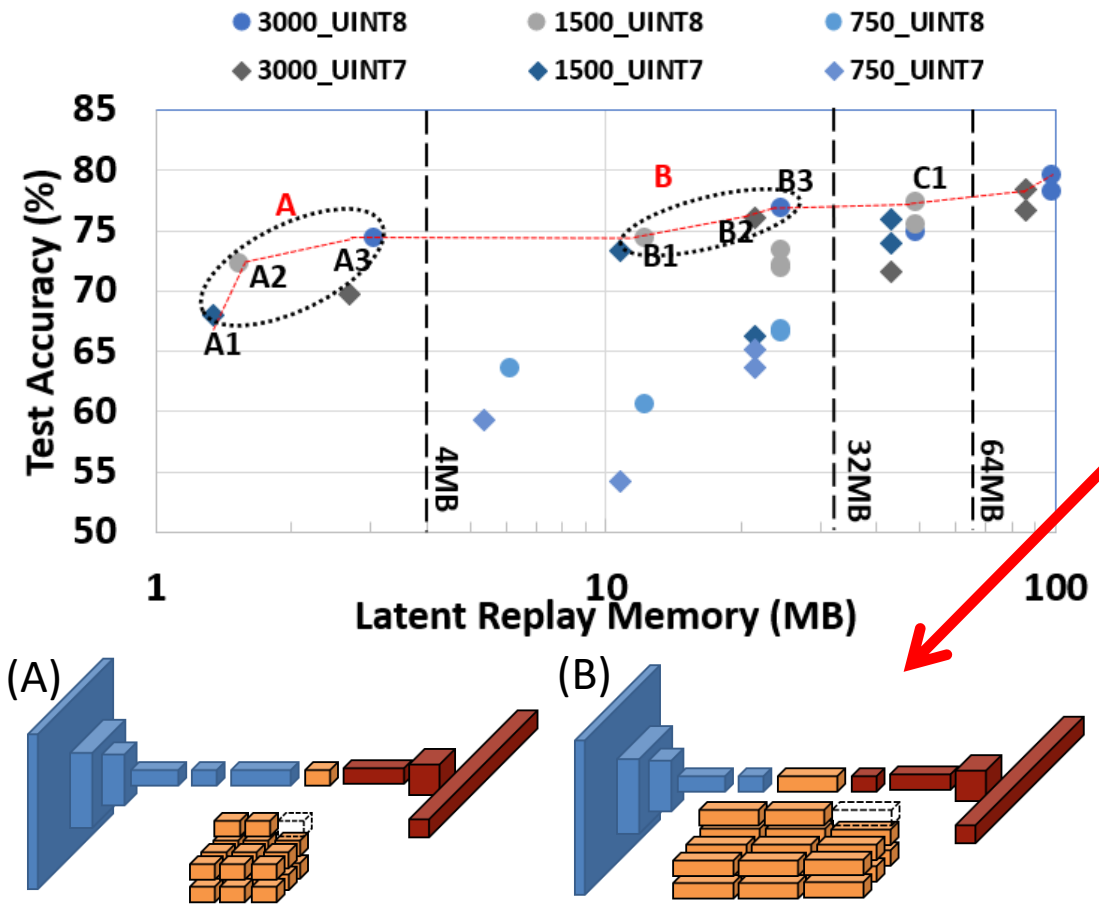

- Memory and Accuracy requirements **vary depending on the LR layer**.
- Quantization of LRs to **INT8 leads to no accuracy loss** with respect to FP32.
- The **LR layer depth** and the **precision** impacts on the accuracy.
- We report the bounds **4, 32 and 64 MB**, which are sizes compatible with embedded devices memories.
- We are able to **retrain on a new class of object**, within few seconds (about 6s).

Journal under review is available at:
https://drive.google.com/drive/folders/1Htabat8Fc_ttMYydm2PIO_f_eCFvjjrR?usp=sharing

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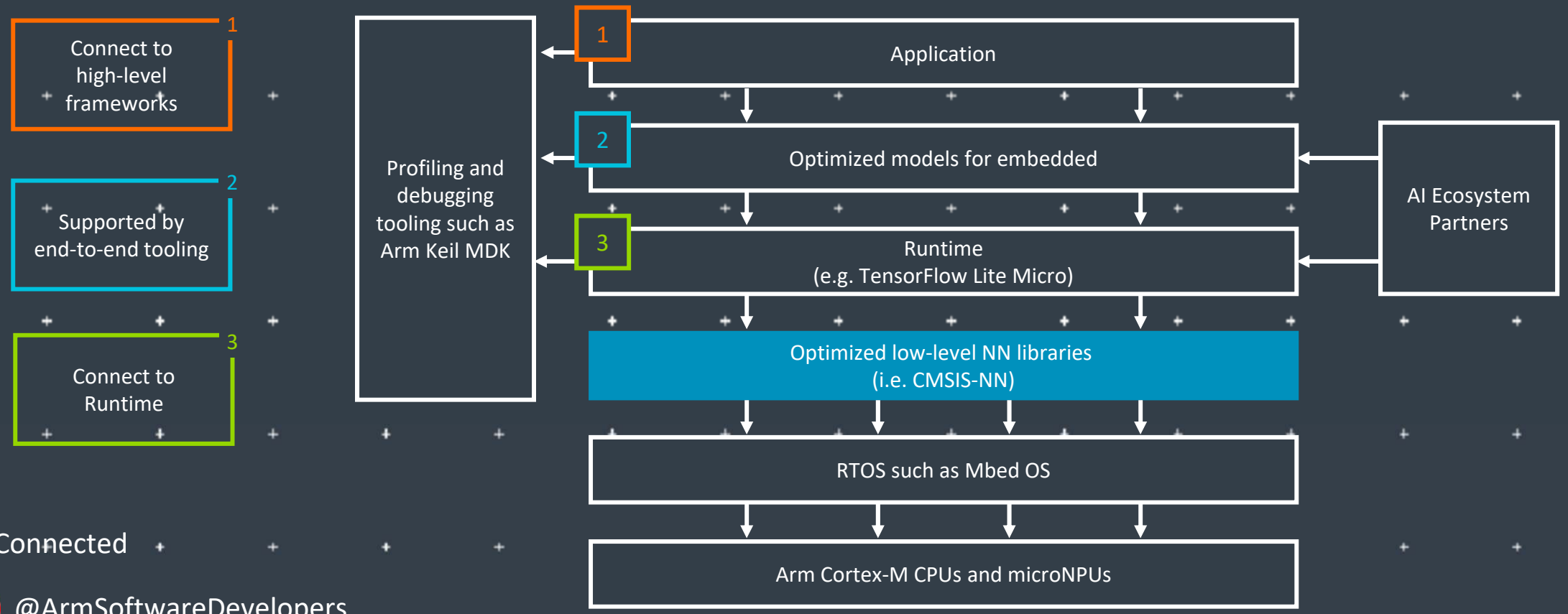

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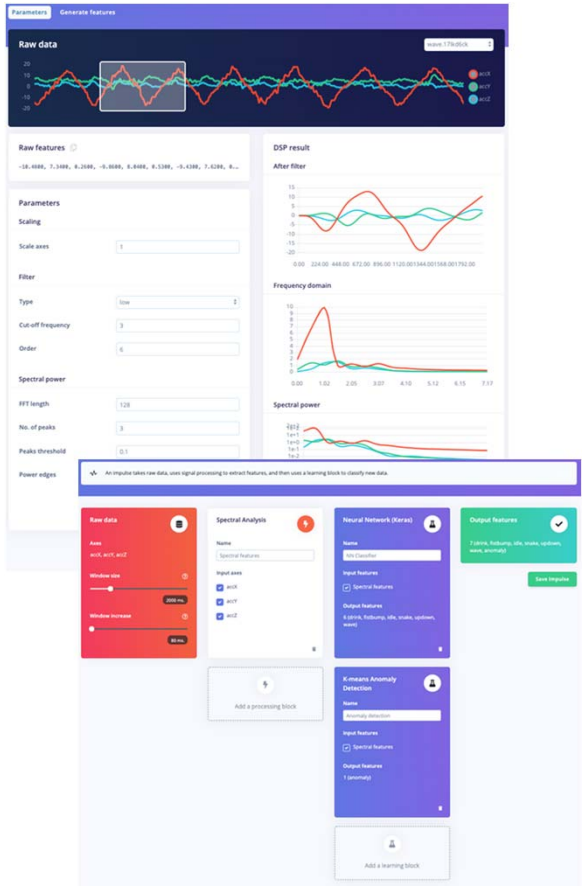
Test



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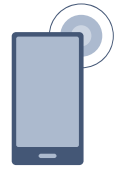

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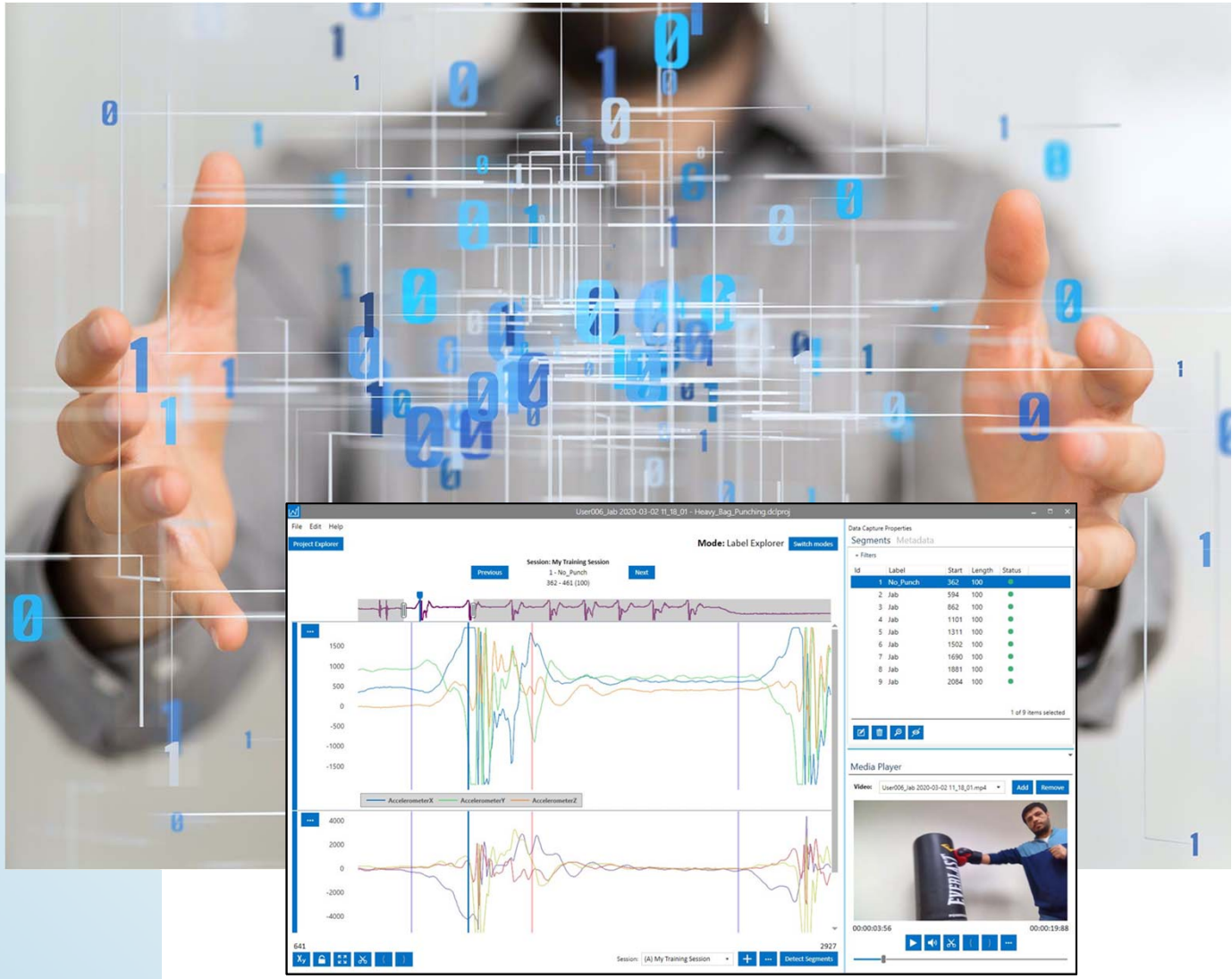

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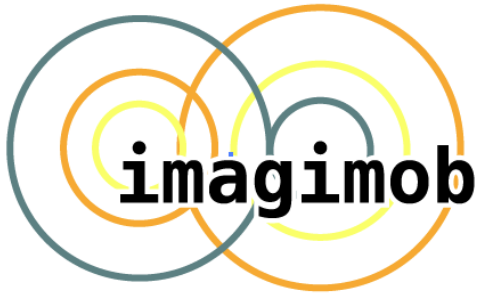

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