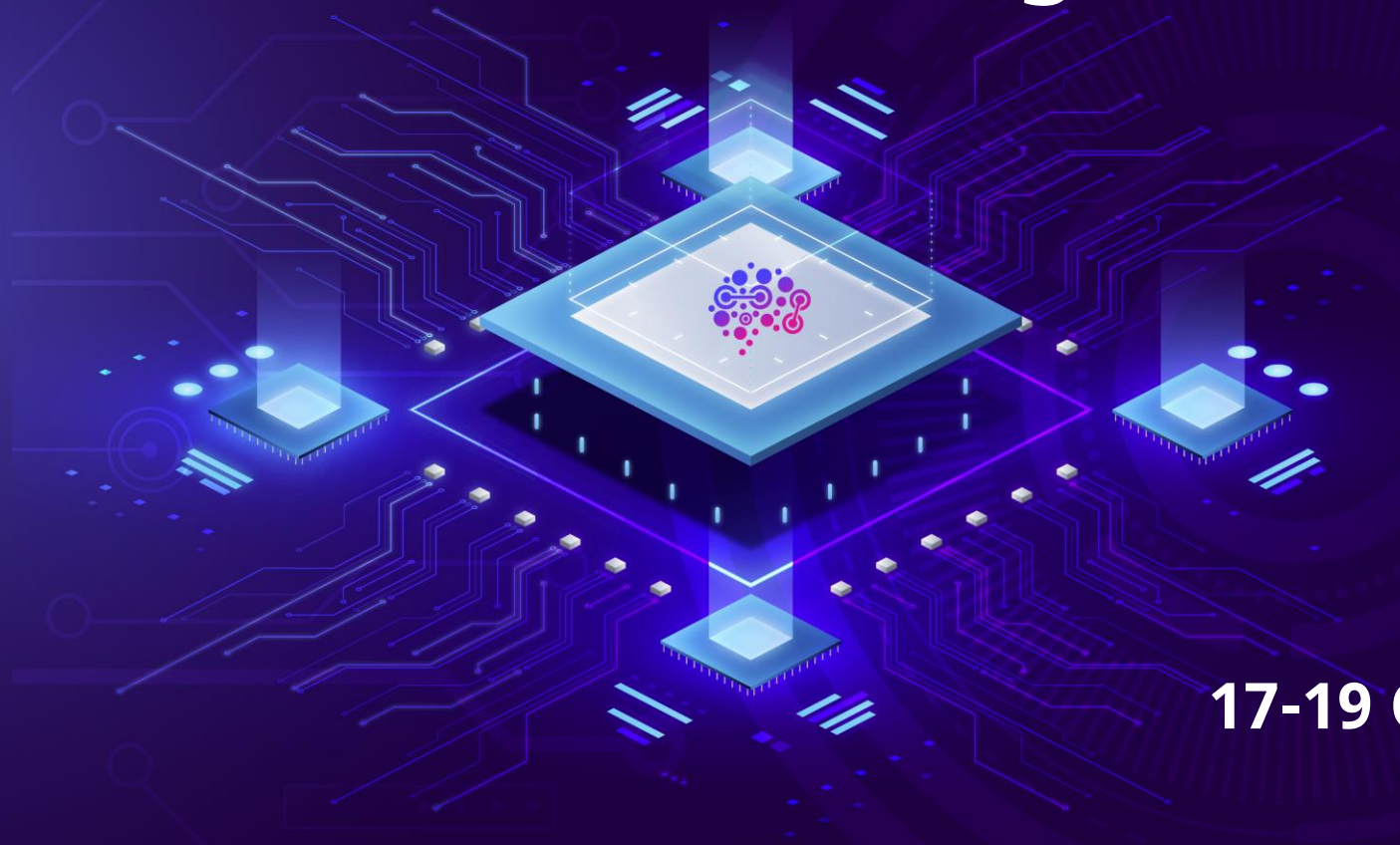
European Conference on EDGE AI Technologies and Applications - EEAI



Advancing emerging edge AI technologies and driving next generation intelligent applications.

17-19 October 2023, Athens, Greece

European Conference on EDGE AI Technologies and Applications - EEAI

Ultra-low Power Car Plate Recognition at the Edge

Dávid Isztl, Institute of Embedded Systems (InES), ZHAW School of Engineering, Switzerland

17-19 October 2023 Athens, Greece

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Research Goal

Tracking car plates with AA batteries for 3 years?

Source: https://www.worldatlas.com/r/w1200/upload/89/8a/b3/shutterstock-476995468.jpg

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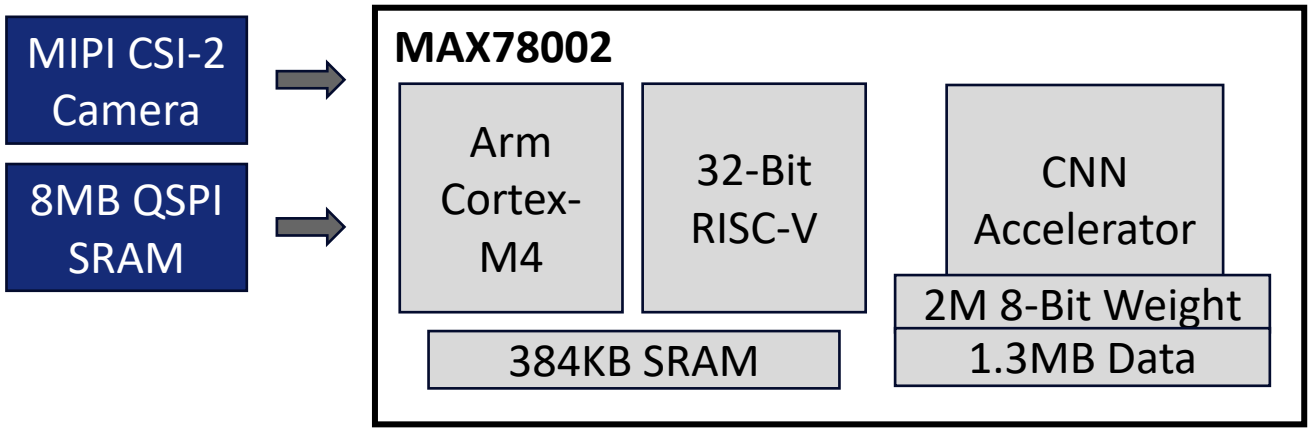
Our goal

Maxim Max78002

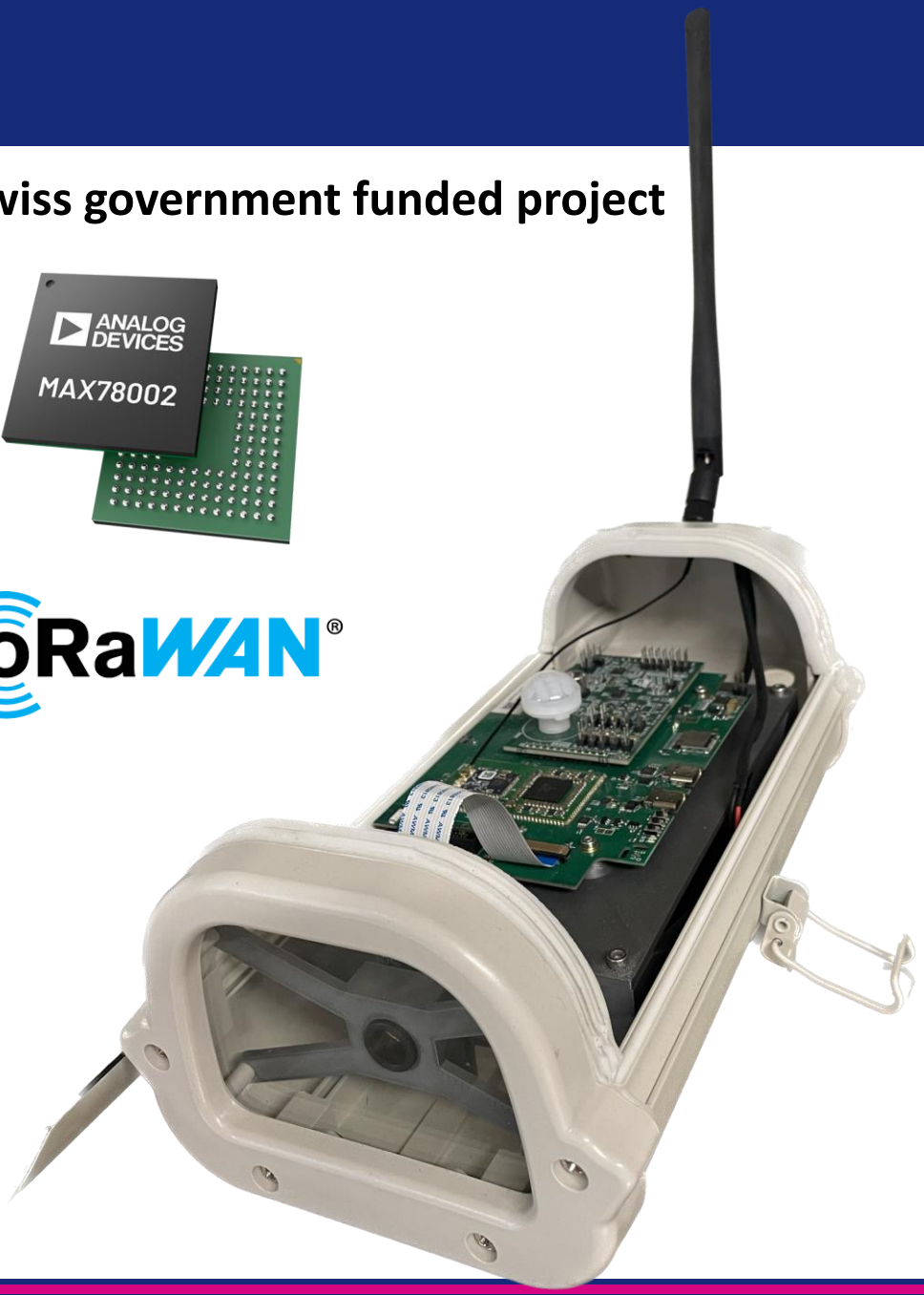
All in *one package*
Average Power during Inference ~ 70 Milliwatt
Peak Power during Inference ~ 500 Milliwatt
Sleep Mode ~ 1 Milliwatt

Goal
Should last **3 years**
Small size, **AAA or AA batteries**
Privacy protection



Swiss government funded project

LoRaWAN®



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Methodology

Classical image processing?

Multi stage micro-CNN?

Reducing the image space?

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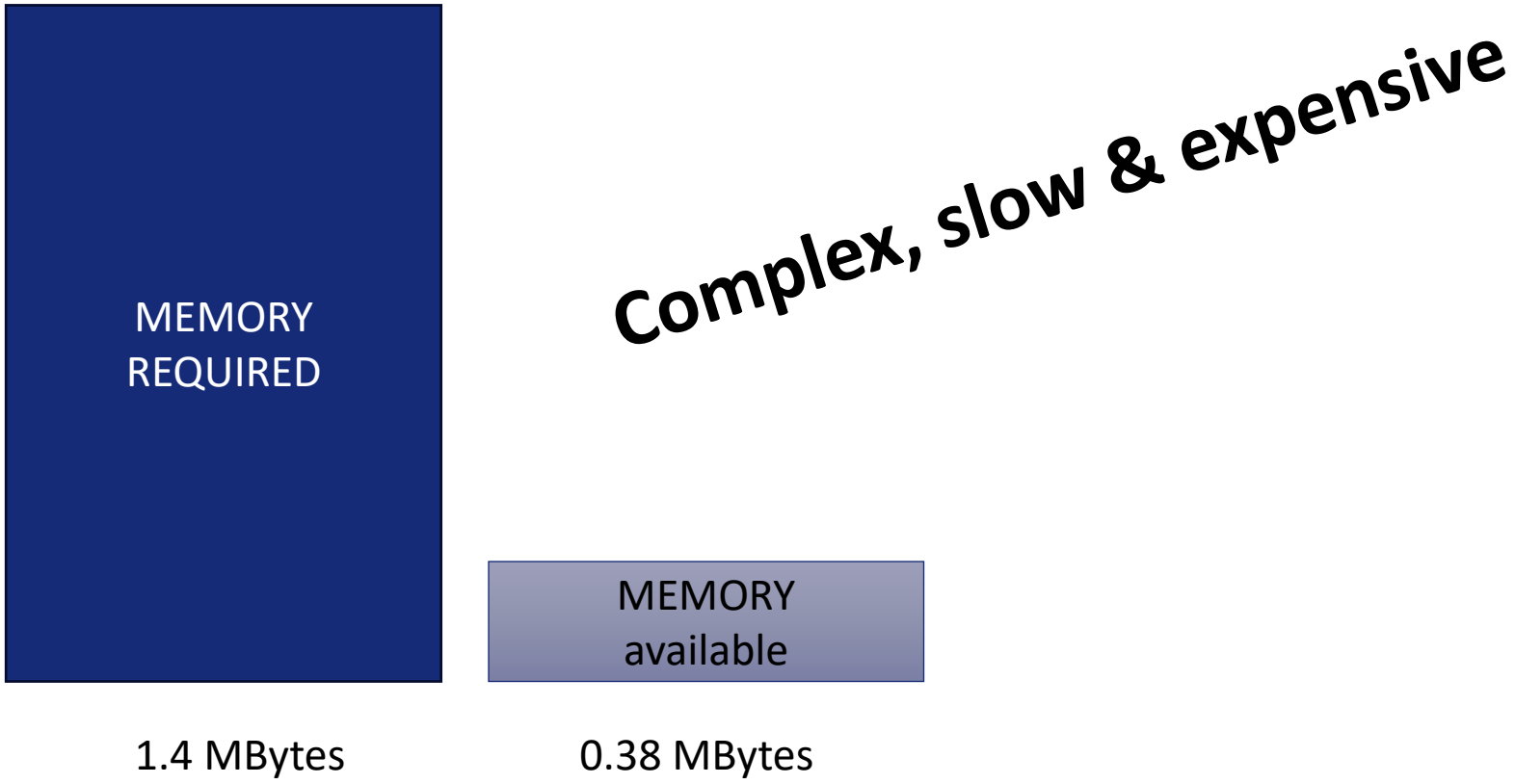
1. Classical image processing?

Full image stored on **external QSPI SRAM**

QSPI SRAM access is **expensive and slow**



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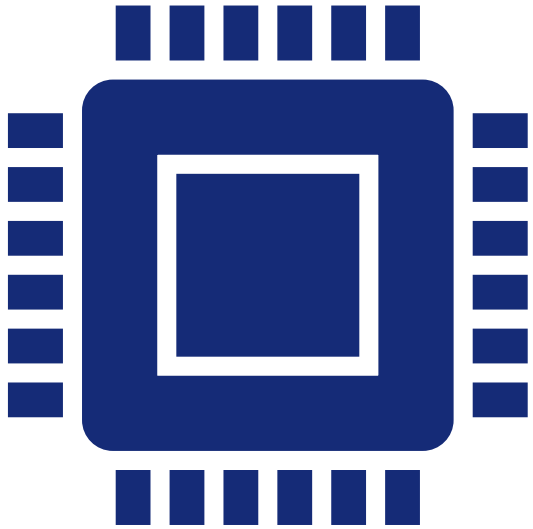
2. Reducing the image space?



16 groups of 4 cores share **81'920 bytes** per group

20'480 bytes per core (channel)

This limits the resolution to **143x143 pixels in HWC**

Full resolution means: the memory is full!

Reasonable size is **88x88**

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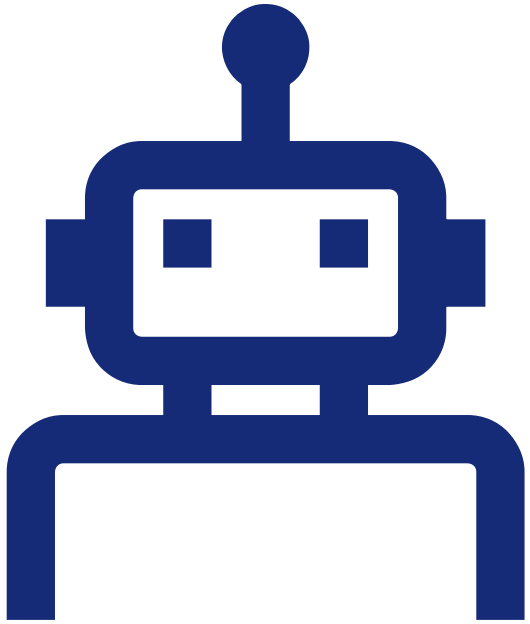
3. Multistage micro-CNN?



Dimensionality reduction

Plate **localization**

Characters **localization**

Characters recognition (**classification**)

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Design and Implementation

4 **Gather**: CCC444

Downsampled from original image 800x600x3 **Reshaped** into 88x88x3 **Padded** to maintain the aspect-ratio

Downsampled from select area HxWx3 **Reshaped** into 88x88x3 **Padded** to maintain the aspect-ratio **Resizable height** by dynamic padding

Classified using CNN

Trasmitted via LoraWAN

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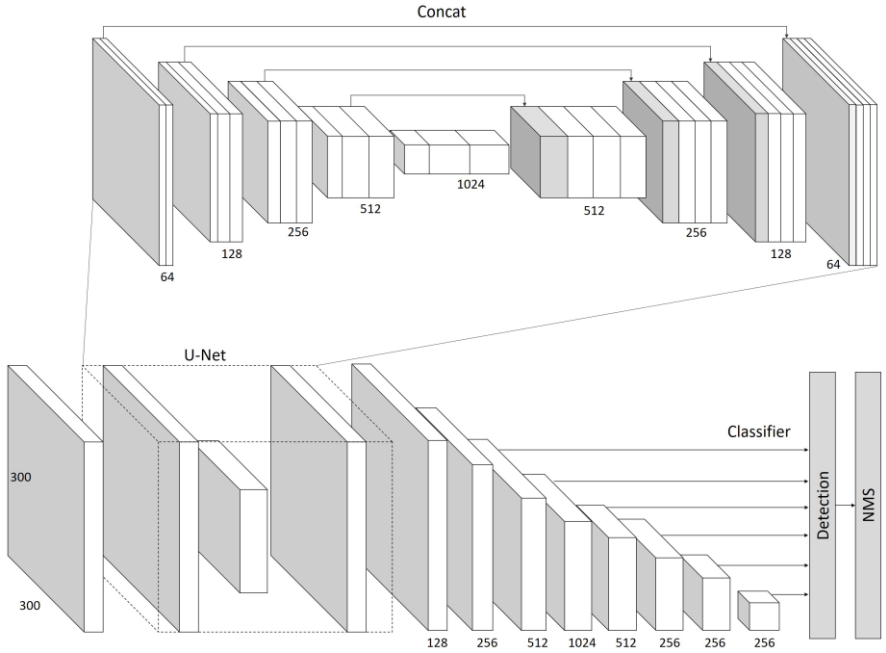
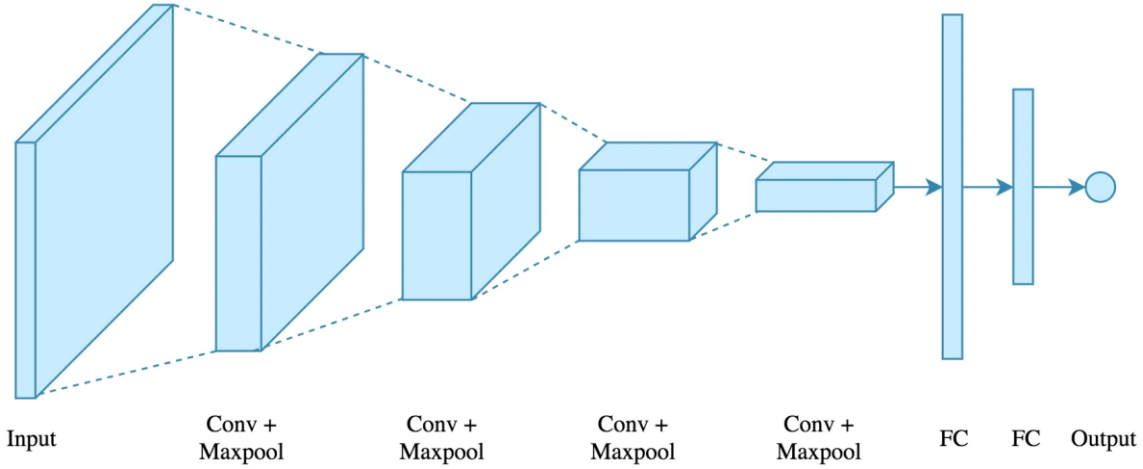
Design and Implementation

Unet+SSD = U-SSD



1. **Plate locator**, 415 kbytes
2. **Characters locator**, 415 kbytes

CNN Classification



3. **Characters classifier**, 304 kbytes

Total: 1.13 Mbytes of weights

Note: an average **TensorFlow lite mobilenet v2 SSD contains ~3.3** Mbytes of weights

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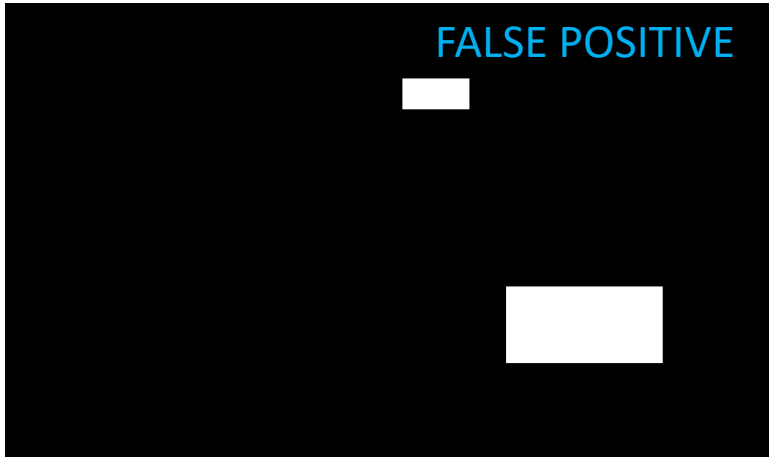
Experimental Results

Unet

Unet

Unet



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Experimental Results

Unet

SSD

SSD performs **coordinate prediction**
False positives are filtered out
SSD is trained to fit the Unet

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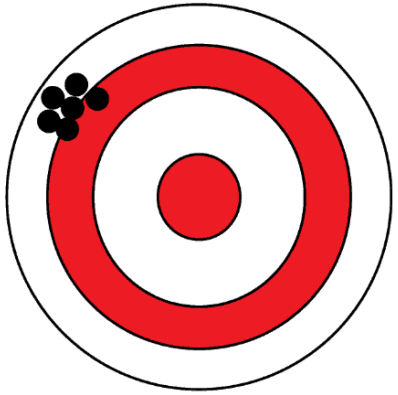
Experimental Results

Model	Resolution	Accuracy		Latency (ms/img)
		FP32	QAT INT8	

Total inference time for one plate: **0.035 seconds**
Average Inference power consumption: **0.07 W**

LOW ACCURACY, HIGH RECALL (precision)



The solution **appears to be:**
Fast (when compared against sliding window)
Energy efficient

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Future Research

Improve the overall accuracy…

Bottleneck appears to be the **character locator**

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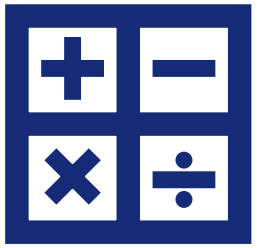
Conclusion

Do not underestimate **1.13 Mbytes** of weights!



Dimensional reduction is key

Pyramid approach for low memory & power profile

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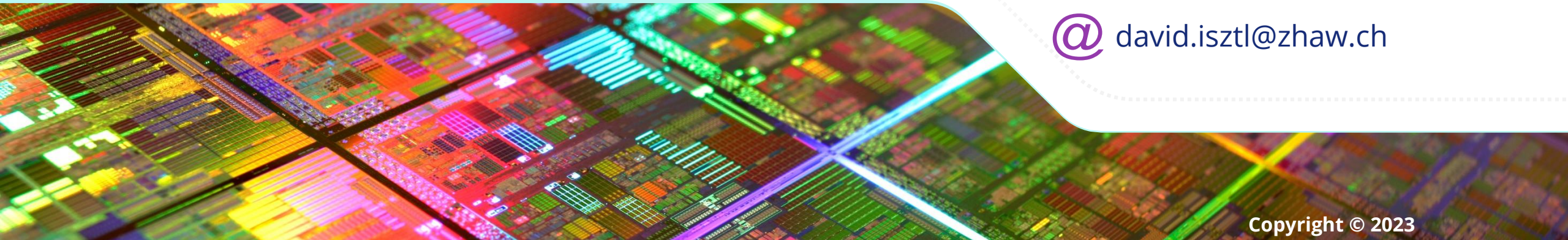
EDGE AI

Thank You

For your attention



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