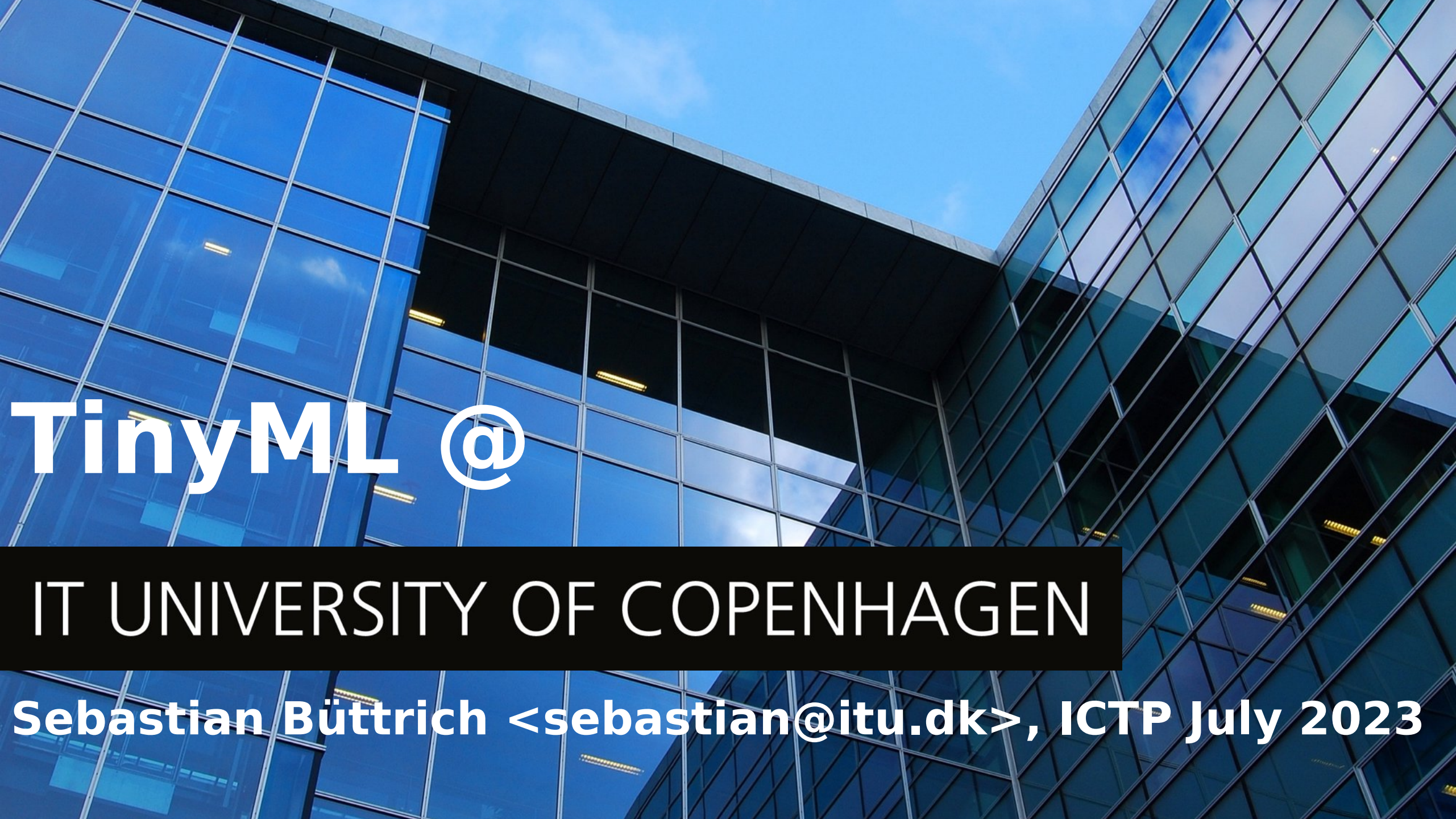


Sebastian Büttrich <sebastian@itu.dk>, ICTP July 2023

IT UNIVERSITY OF COPENHAGEN

IT only! 3 Institutes: CS, Digital Design, Business IT
800 staff, 1200 MSc students, 1100 BSc students

IT UNIVERSITY OF COPENHAGEN

Data Intensive Systems and Applications

Specializations: Data Systems, IoT
DASYALab: IoT, Networks & Hardware Lab

https://dasya.itu.dk

DASYA Lab

IoT, Networks* & Hardware Lab

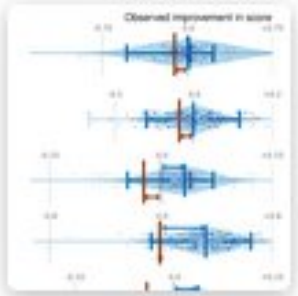
https://dasya.itu.dk

* a lot of low power LPWAN, LoRa, etc →

THE THINGS NETWORK COPENHAGEN

ML at the IT University:

A lot of NLP, LLM, some ML in medical imaging, robotics, gaming …



Machine learning for medical imaging: methodological failures and recommendations for the future

Gaël Varoquaux, and Veronika Cheplygina

NPJ Digital Medicine 2022

Altmetric 294

A cat is a small, carnivorous mammal that is often kept as a domestic pet. It belongs to the Felidae family and is known scientifically as Felis catus. Cats are characterized by their slender bodies, sharp retractable claws, and highly flexible movements. They have a variety of coat colors and patterns.

TinyML @ IT University: Still in its early phase.

But growing interest in sustainable power aware computing

… e.g. MOTH (ML on Tiny Hardware)

CCIT researcher Pinar Tözün secures grant to develop the computing power of small devices

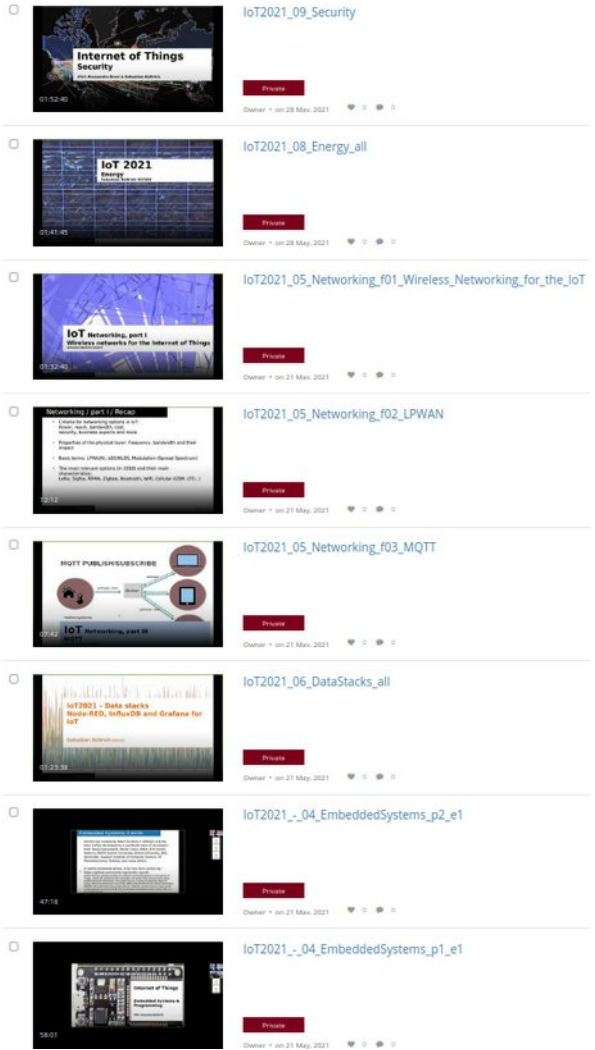
Associate Professor at the Department of Computer Science Pınar Tözün has secured 2.7 million kroner from the Novo Nordisk Foundation to develop novel mechanisms to get more value out of data using the computing power of small devices. The research project is entitled *Machine Learning on Tiny Hardware (MOTH)* and is slated to run for three years, beginning August 2023. Read more about the project and Tözün's research vision here.

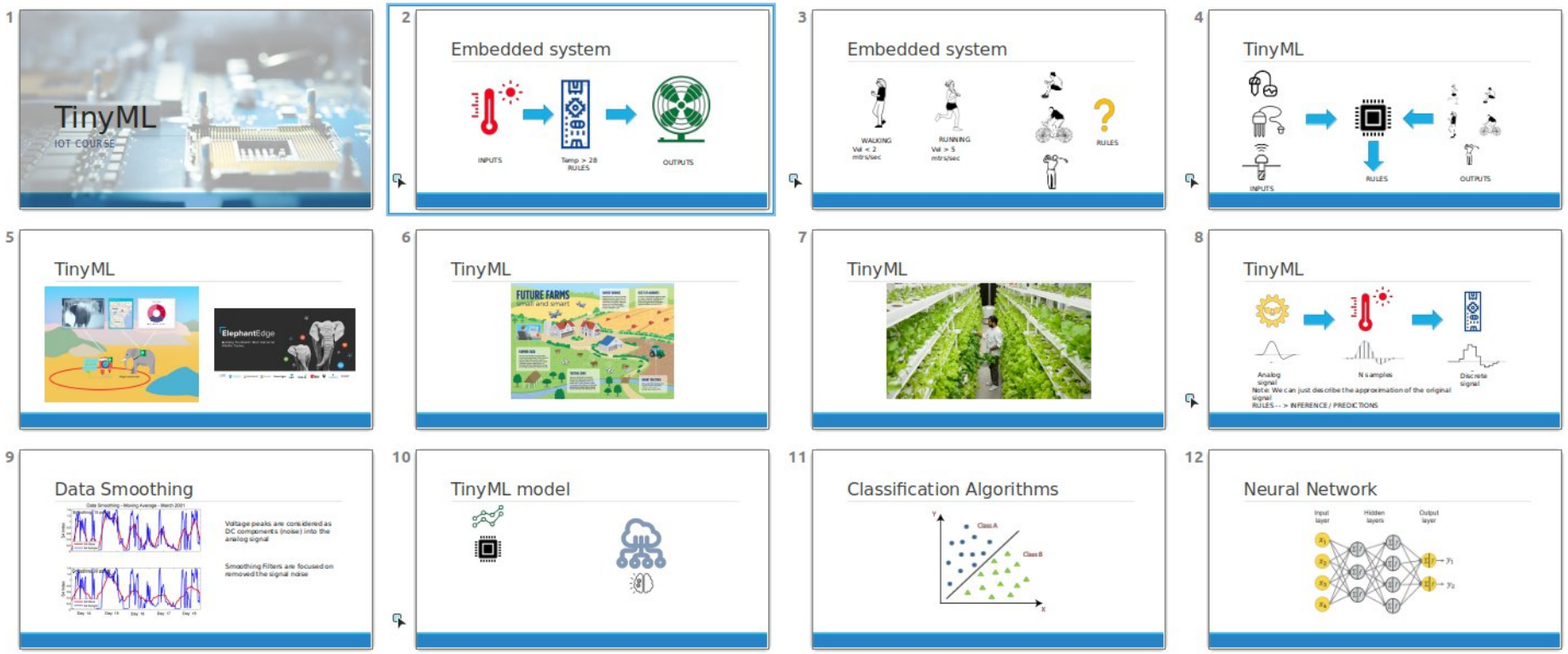
… but mostly still in the 10 … 100 Watt region.

Mindset: power and connectivity are never a problem.

IoT course: MSc elective – hybrid - as part of this,

One to two lectures on Edge Comp & TinyML





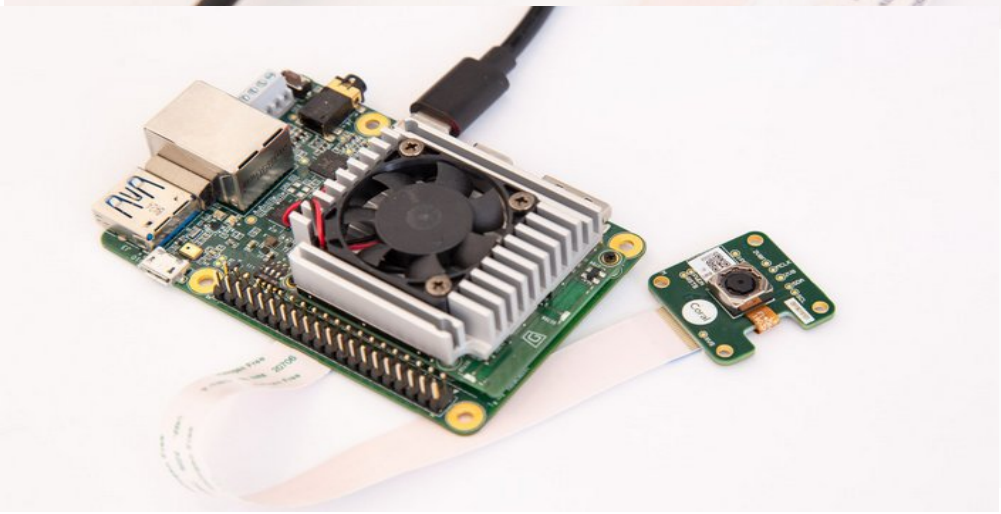
TinyML mostly in Bachelor & Master projects.

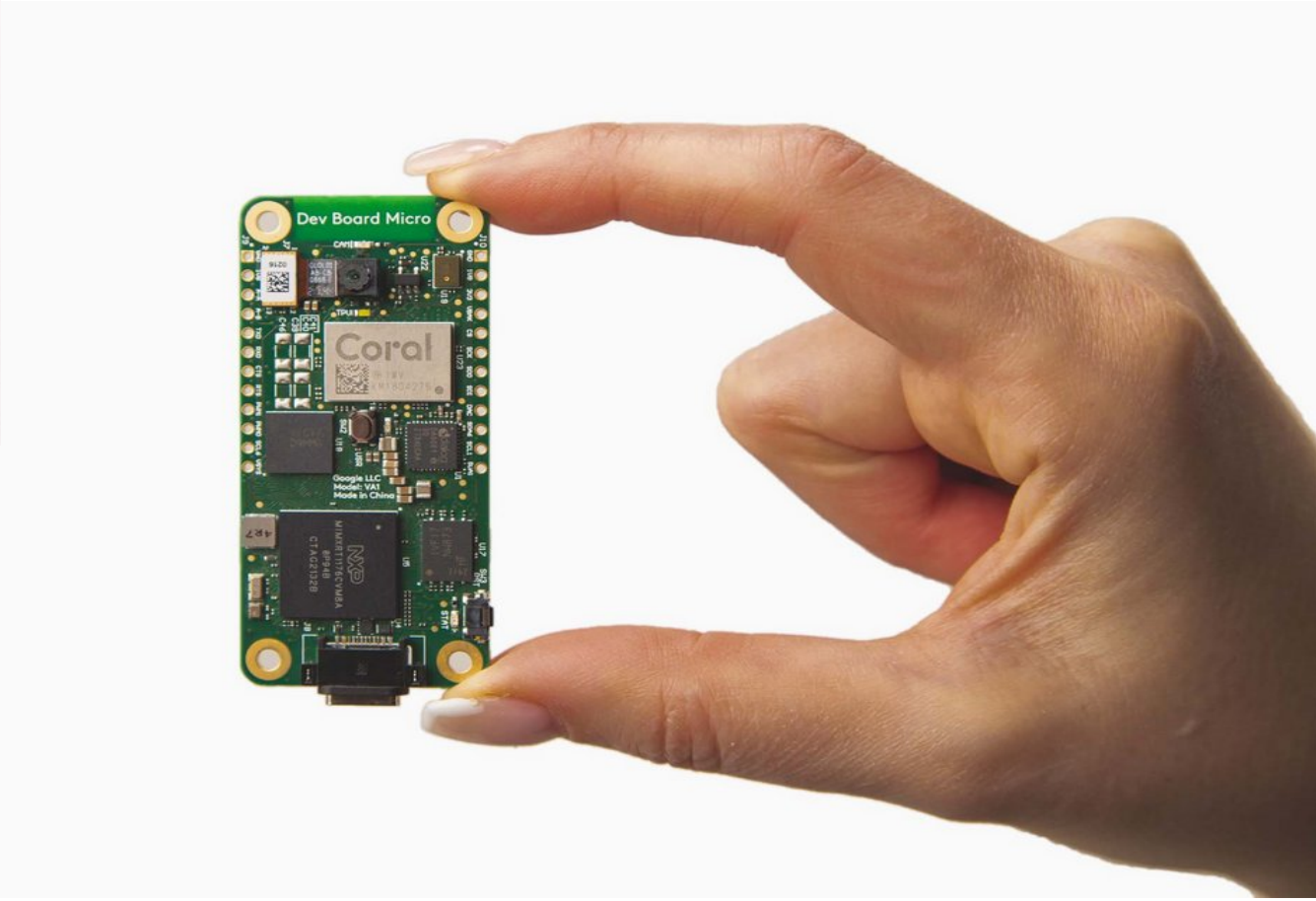
Software & Hardware: the usual suspects -

Tensorflow (lite, micro), Jupyter Labs, Colab, Edge Impulse, Arduino, ...

ESP32 (Pycom class kits, others), TTGOs, CubeCell Arduinos (TinyML class kit), Portenta, Nicla, Nvidia Jetson (all sizes), Google Coral TPUs, ...

Hardware for TinyML: Google Coral TPU





source: https://coral.ai/docs

Started with fun projects ... (what lab manager thinks is fun)

Inferencing...

gibson

Time per inference: 6 ms.

GIBSON

0.94

Inferencing...

fender

Time per inference: 6 ms.

FENDER

0.85

FENDER

0.06

TinyML @ ITU: Birdcams & Scarecrows

Data science is easy –

when your data comes
from Kaggle.

Else, not so much …

source: kaggle

TinyML @ ITU: Birdcams & Scarecrows

Data is hard!

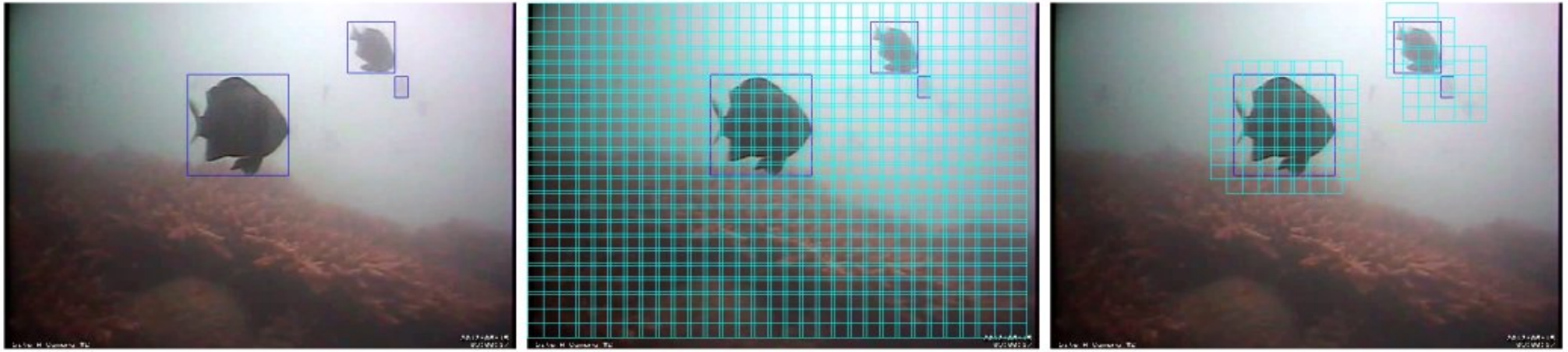
Also, remember twigs …

(warning: ML creates black boxes)

source: Steen Heesche Petersen and Tin Marecic

TinyML @ ITU: Fishcam, Coral Reefs

Project – **looking for collaborators!**
with Copenhagen Aquarium, Partners in Zanzibar, Kenya, California (MBARI), others …



(a) Bounding box (b) All windows (c) Windows labeled "fish"

source: DASYA, Jens Joergensen

TinyML @ ITU: Fishcam, Coral Reefs

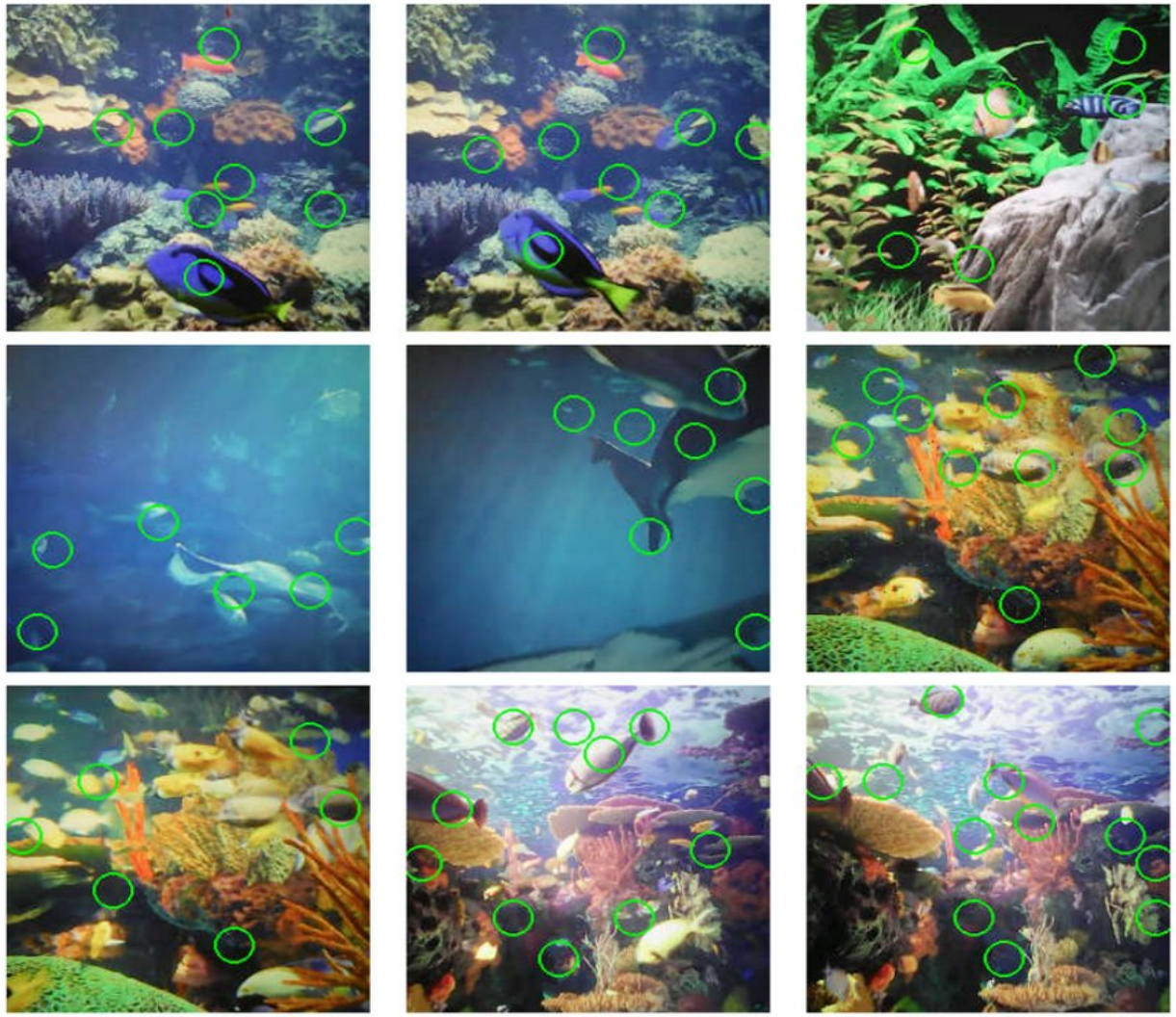


Figure 24: Examples of images with marked fish

source: DASYA, Jens Joergensen

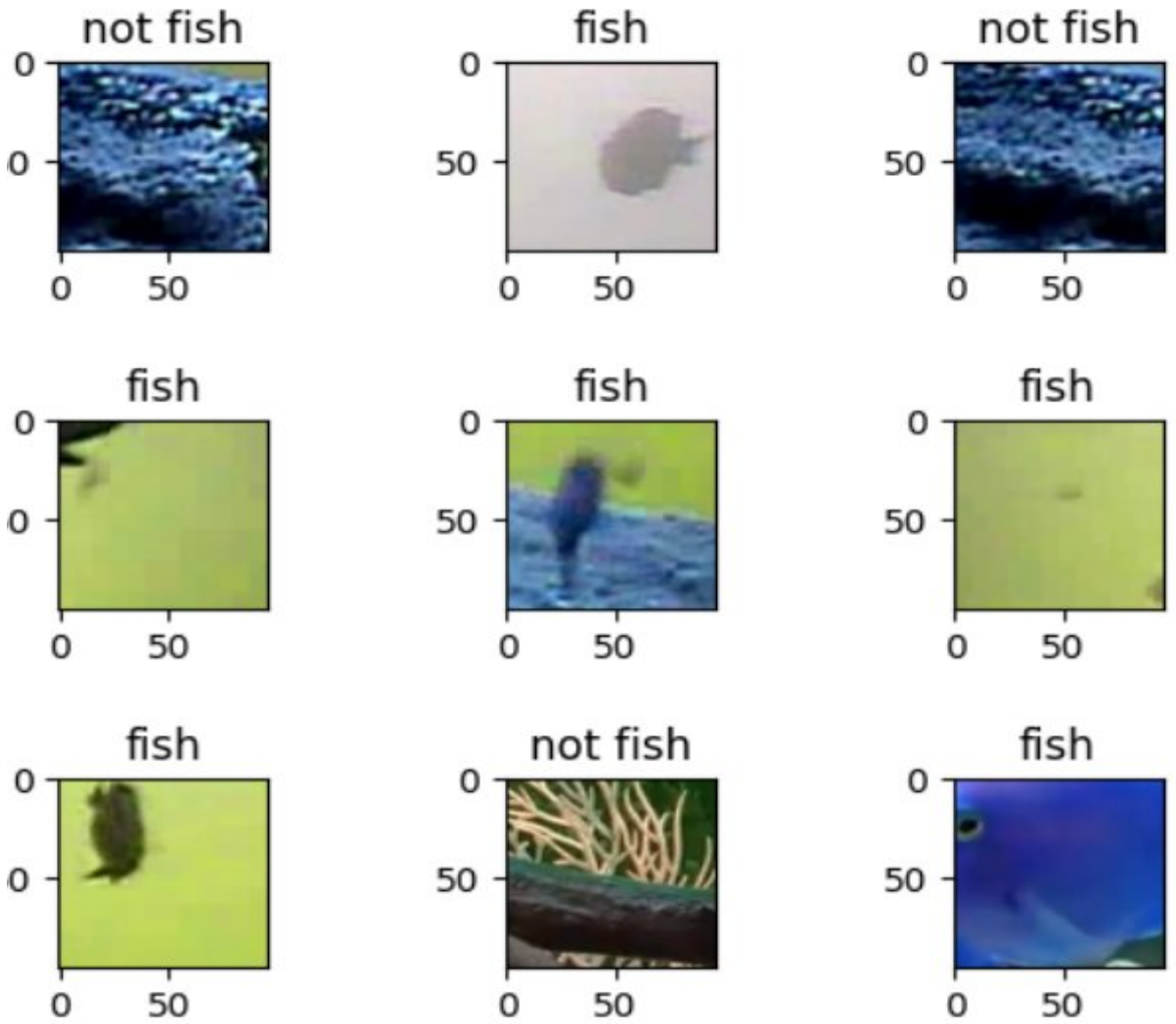
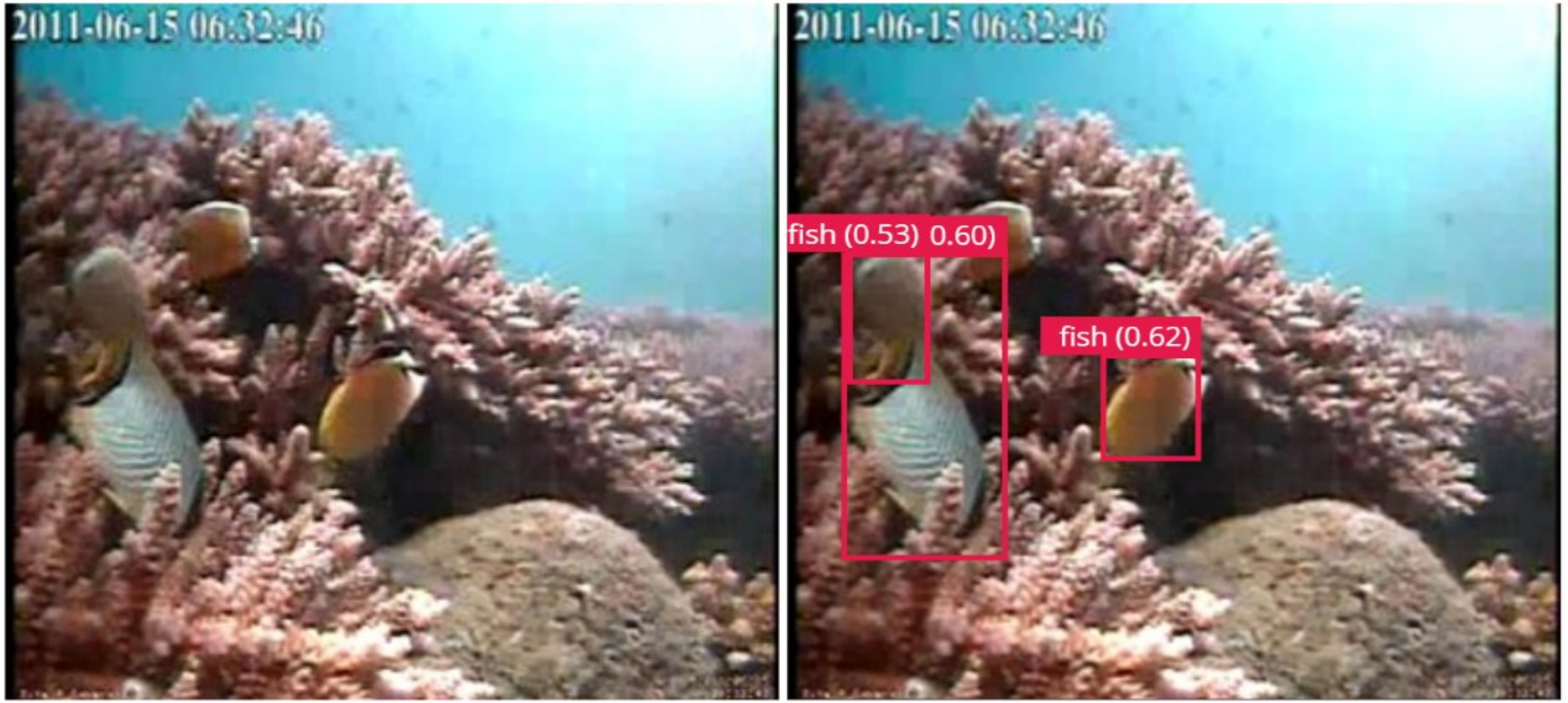


Figure 15: Sample of the training data for the classifier

TinyML @ ITU: Fishcam, Coral Reefs

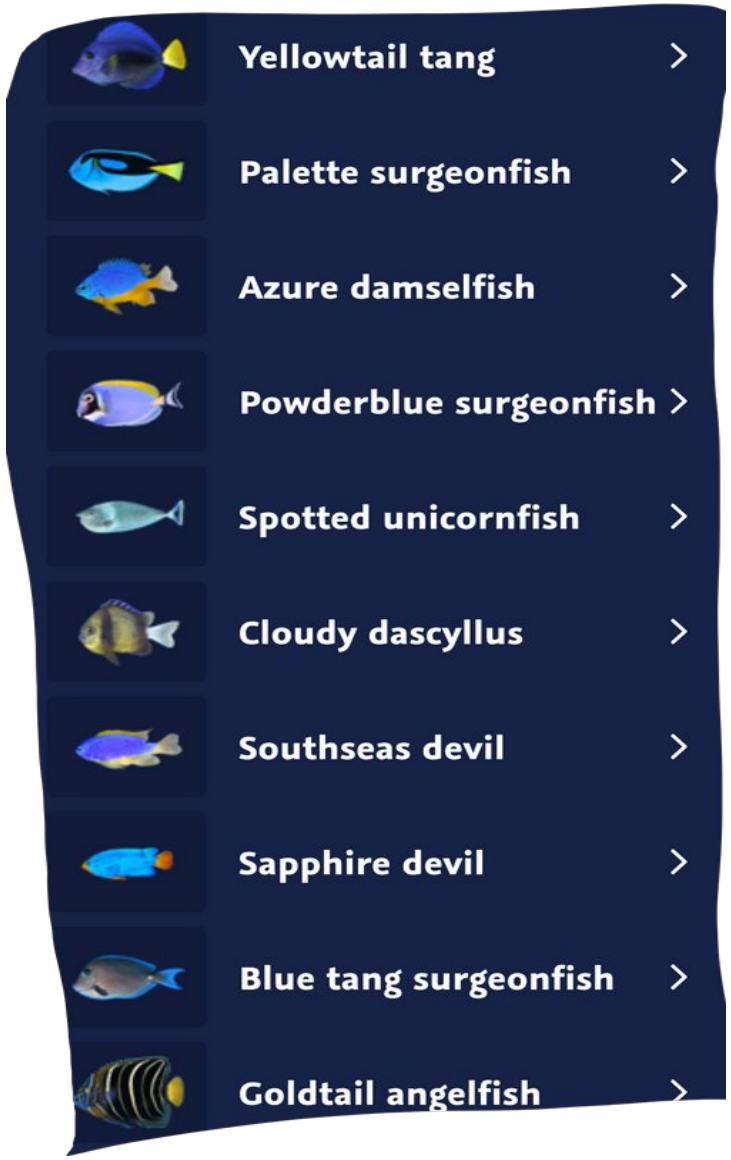


(a) Input image (b) Bounding box result

Figure 16: Bounding box object detection result

source: DASYA, Jens Joergensen

TinyML @ ITU: Fishcam, Coral Reefs



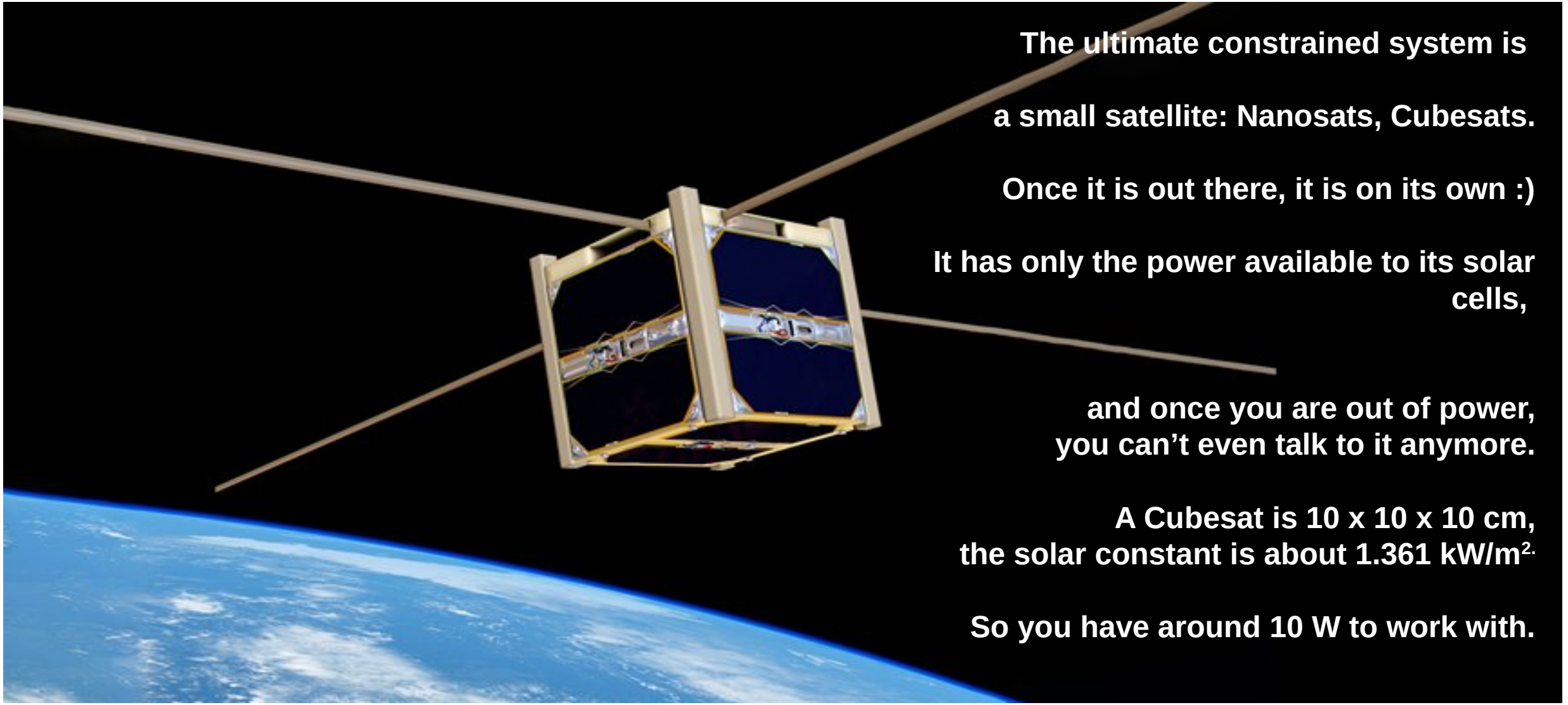
(a) Single class FOMO

(b) Multi class FOMO

Figure 25: Comparison of single class vs multiclass FOMO

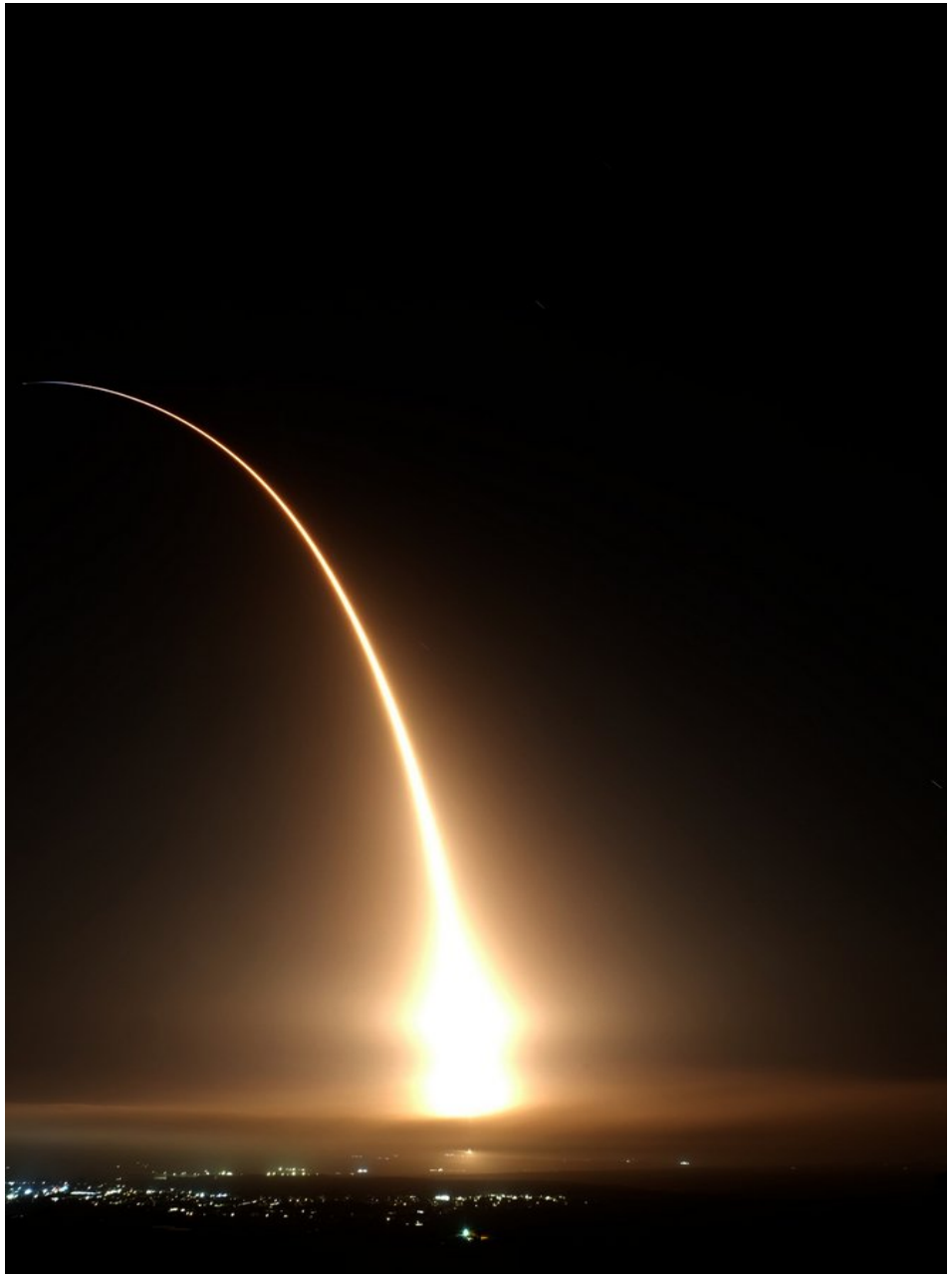
source: DASYA, Jens Joergensen, Sebastian Büttrich

TinyML @ ITU: DISCOSAT (satellite based ML)



source: discosat.dk

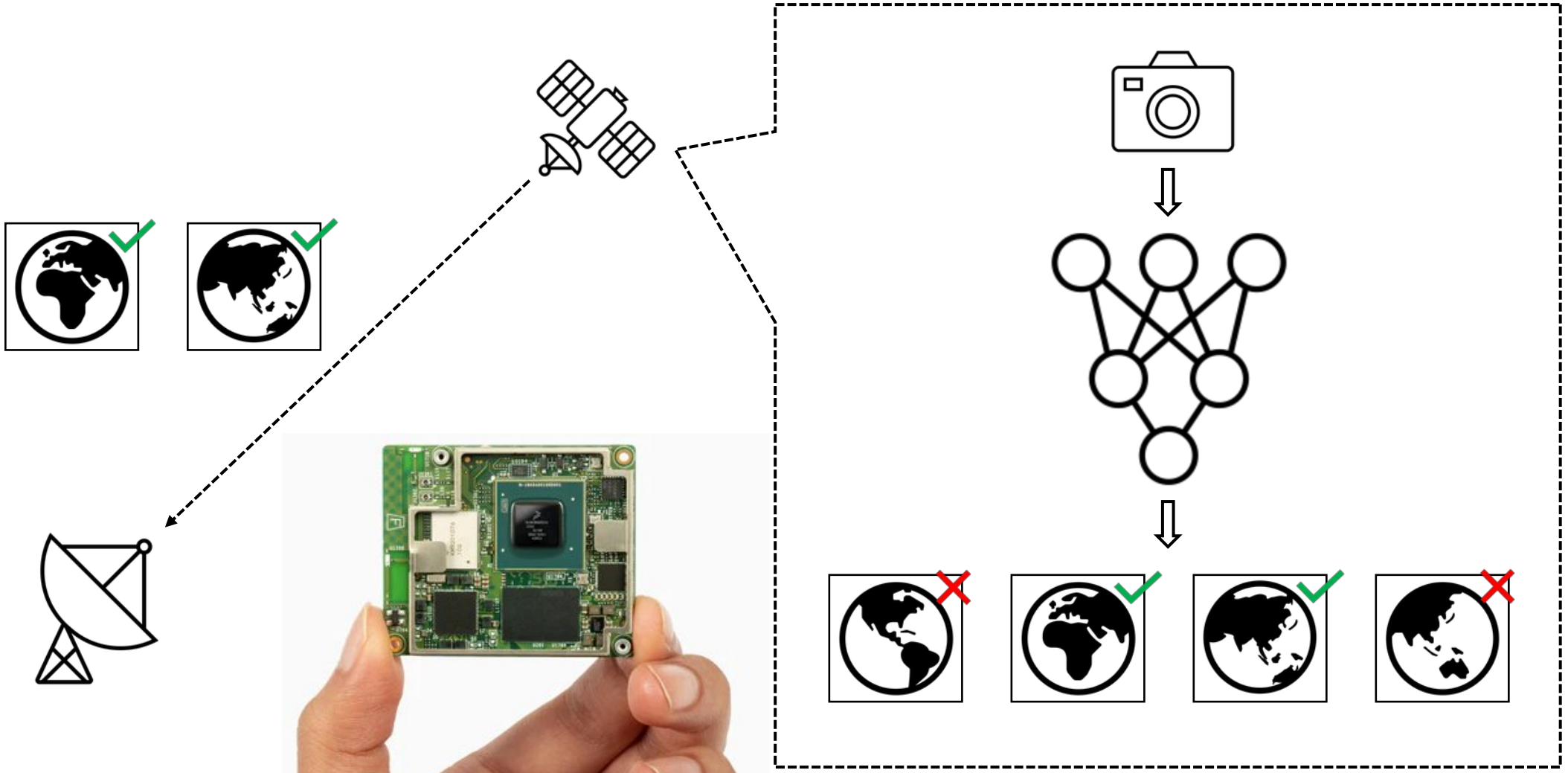
TinyML @ ITU: DISCOSAT (satellite based ML)



Mission patches are difficult … ;)
Launching satellites is not a very sustainable activity ..

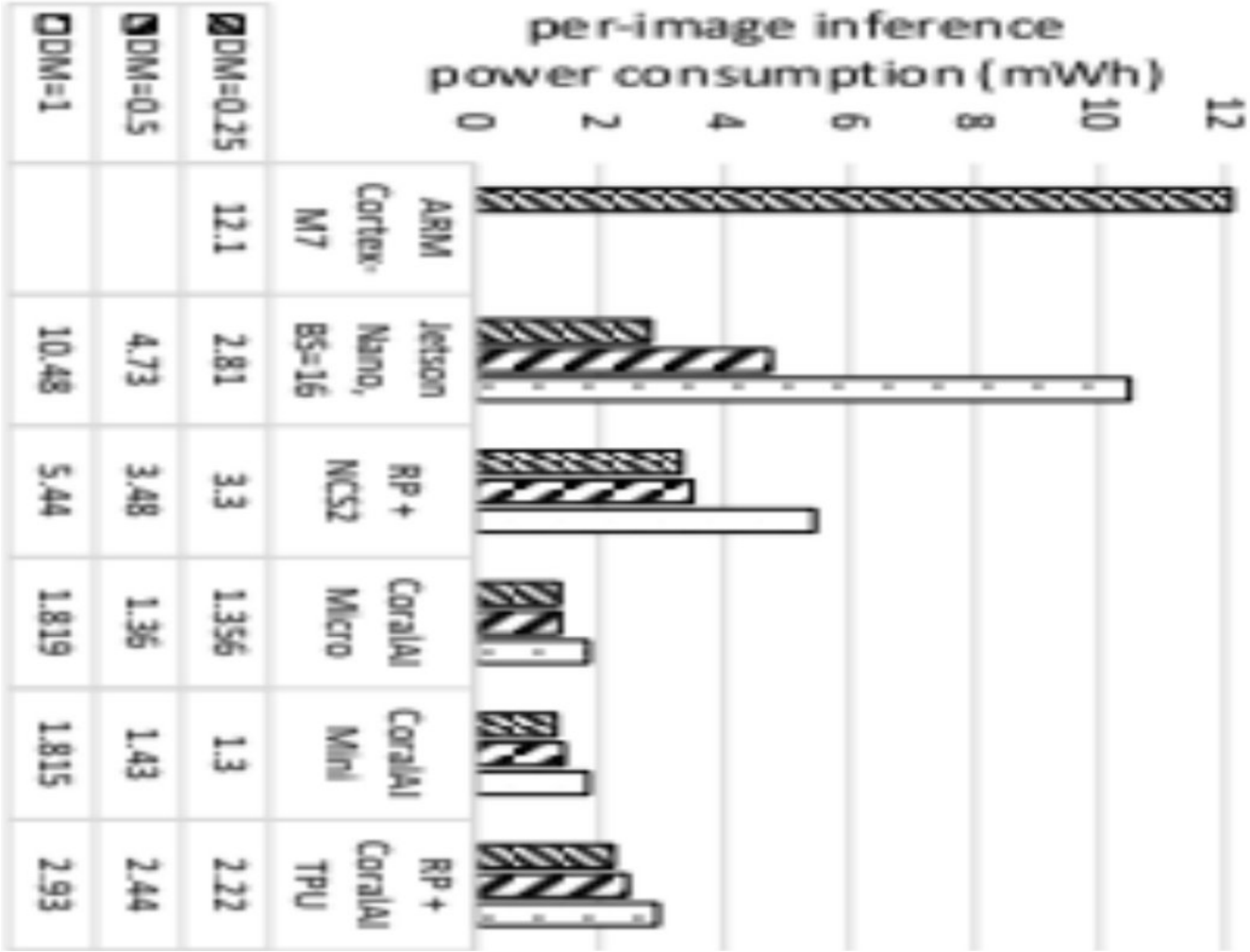
source: discosat.dk, picture: Julian Priest

Machine Learning on Satellites



On satellite, power consumption is key

- **Coral AI TPUs most efficient**
- Jetson Nano too high, though nice low latency
- ARM’s low power draw can’t compensate for its latency



* Using MobileNetV1 of varying sizes

source: Thesis, Rober Mayer

Ministry for Research and Education

National Partnership for Space Education 2023-25

now has an item **(owner: IT University)**

Machine Learning in Space (on Tiny Satellites)

… hence, TinyML

We are planning a series of DIY Satellite Building for Schools and Universities.

Kick-off meeting at …

PIONEER CENTRE FOR ARTIFICIAL INTELLIGENCE

Thank you!

Reach me at

sebastian@itu.dk
sebastian@nsrc.org