European Conference on EDGE AI Technologies and Applications - EEAI

ANDANTE Platform 4.1a :

A Multi-Application Platform Supporting Several Uses Cases in the Domains Digital Farming and Transport and Smart Mobility.

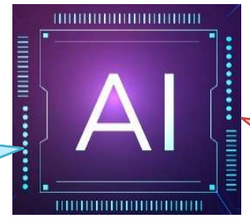
Ivan Miro-Panades (CEA, France)
Enrique Romay (Televes, Spain)
Loreto Mateu Saez (Fraunhofer/IIS, Germany)
Mario Diaz Nava (STMicroelectronics France)

17-19 October 2023 Athens, Greece

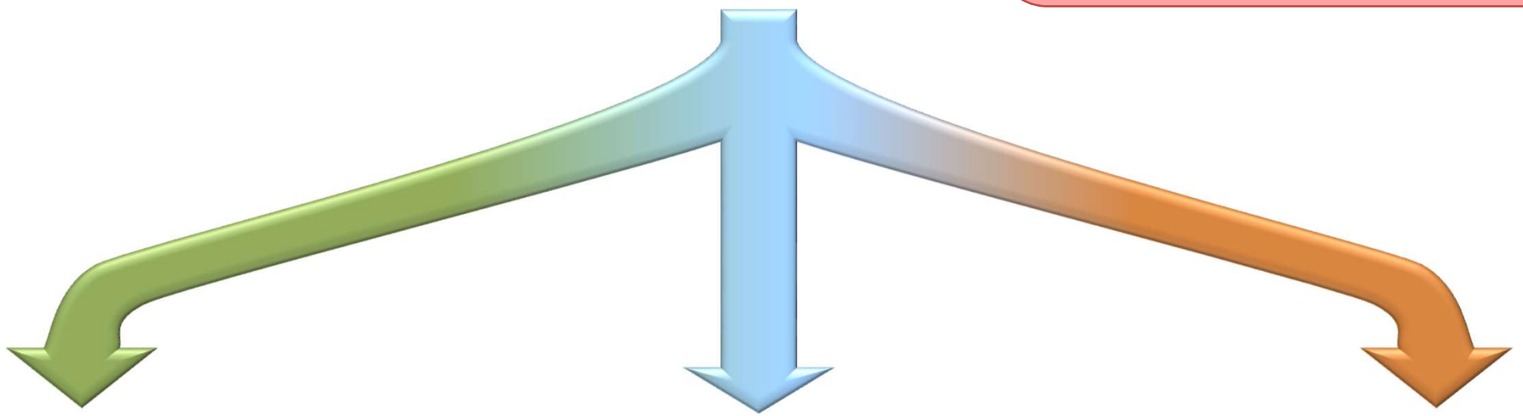
Copyright © 2023

Introduction

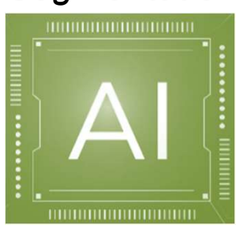
Classification
Segmentation
Object detection
Language models



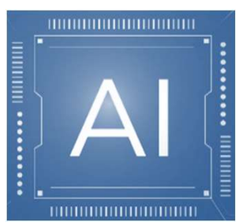
- Generic architecture
- Requires latest technology nodes to achieve good energy efficiency
- High processing latency



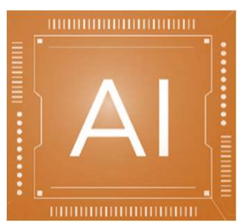
Classification
Segmentation



Object detection



Language models

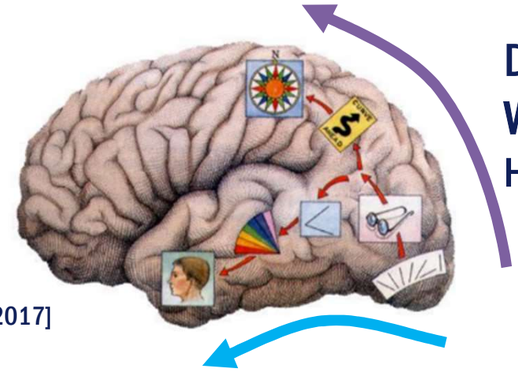


- Specialized architecture
- High energy efficiency
- Ultra low latency
- Doesn't required latest technology node to be energy efficient

Copyright © 2023

Brain bio-inspiration

- Two separate cortical pathways in the visual cortex
  - Dorsal stream: “Where are the objects”
  - Ventral stream: “What are the objects”



[L. Montgomery, 2017]

Dorsal stream
Where: 40ms
High temporal frequencies

Ventral stream
What: 150ms
Low spatial frequencies

Life span stages	Infants			Young children		Older children		Teens				Young adults			
Ages (years)	0 mo	3 mo	6 mo	1	2	4	5	8	11	12	16	20	21	35	50
Visual milestones															
Binocular fusion		↑	→												
Stereopsis		↑	→												
Spatial acuity	↑	↑	↑	↑	↑	↑	↑	→							
Contrast sensitivity	↑	↑	↑	↑	↑	↑	↑	→							
Orientation	↑	↑	↑	↑	↑	↑	↑	→							
Motion	↑	↑	↑	↑	↑	↑	↑	↑	↑	→					
Color perception	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑					
Contour integration	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	→				
Face perception	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	→		

[CR. Siu, KM. Murphy, “The development of human visual cortex and clinical implications”]

- Maturity of visual cortex
  - Development process limited in time
  - The “fixed” visual cortex allows us to continue learning new complex objects at old stage

Copyright © 2023

NeroCorgi Overview

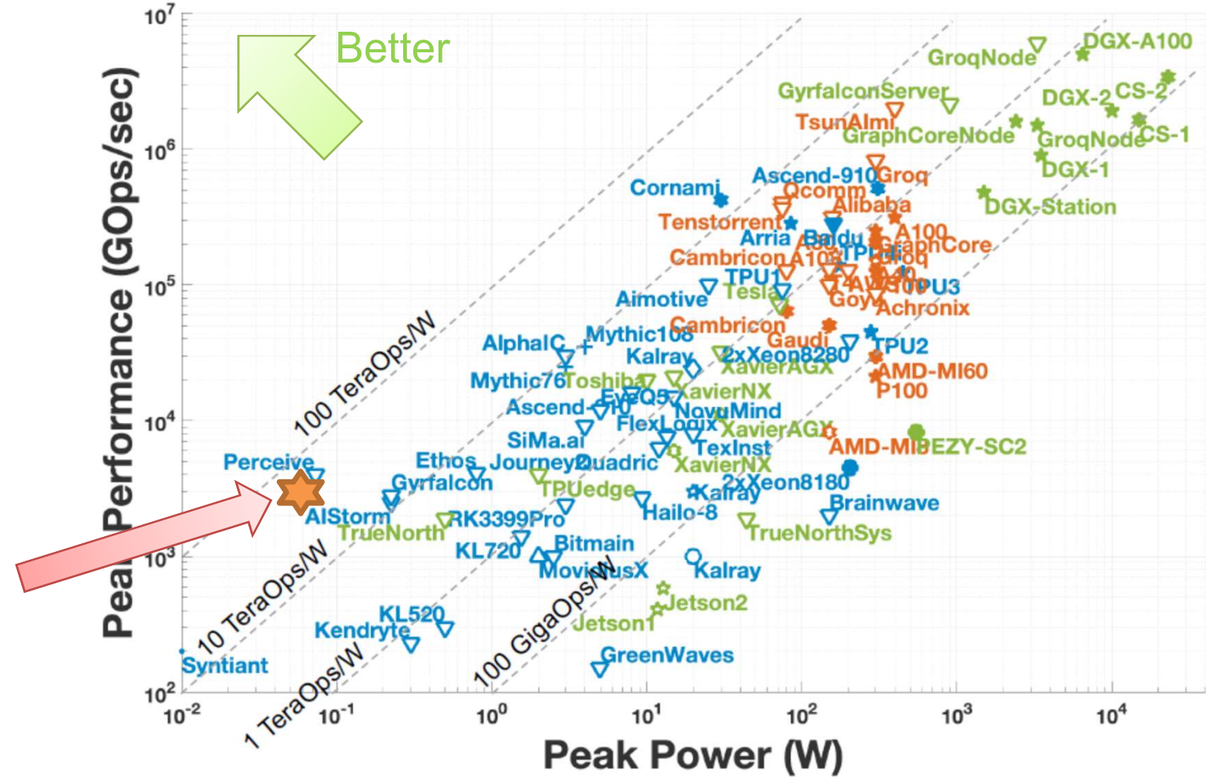
- **Objective:**
  - Low-power low-latency AI accelerator to compute the features of an image to classify and detect objects with a fixed topology and weights
  - HD images of 1280x720pixels at 30 frames per second
  - Preprocessing engine to identify the key points in the image before using a high-end AI engine

ANDANTE

- **Positioning w.r.t. the State of the Art**
  - Best in class energy per inference with HD images
  - Best in class latency with batch size 1

- **Tape-out**
  - GF 22FDX technology
  - Embedding CEA-Leti NVM

Our target



Copyright © 2023

Main pillars

- Ultra low power consumption
  - Energy tradeoff: MobileNet V1 topology
  - Fixed topology and weights
  - 4 bit quantization without accuracy lost compared to FP:
    - Accuracy: 70.54% on ImageNet
- Ultra low latency
  - Inference of top lines obtained even before reading bottom images lines.
  - Streaming architecture.
- Architecture builder
  - Configurable RTL design to multiple architectures and use-cases

Copyright © 2023

NeuroCorgi layers

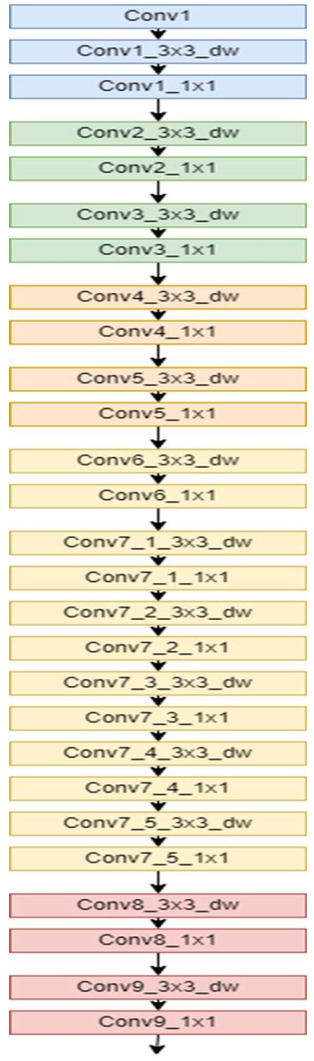
Inputs images (up to 1280x720) RGB @ 30FPS

Output feature map 320 x 180 x 128

Output feature map 160 x 90 x 256

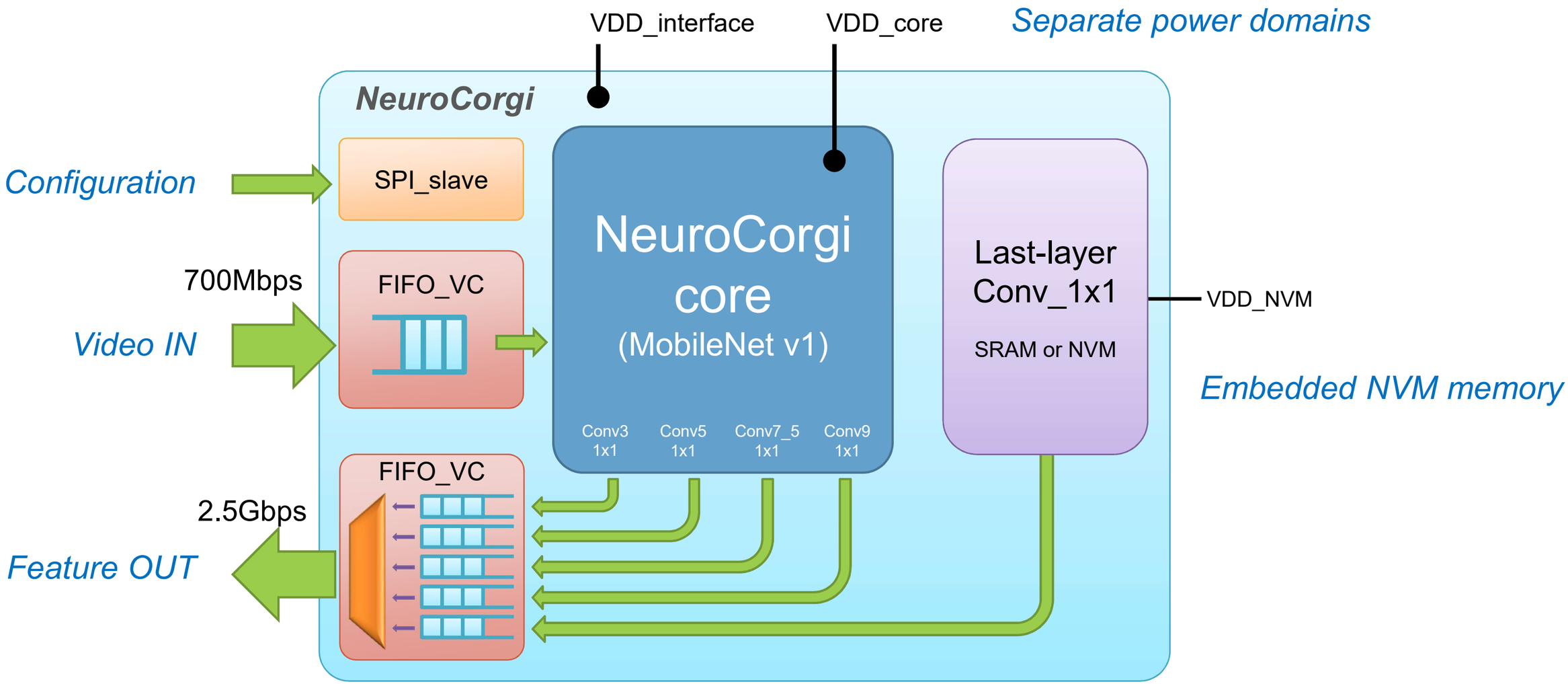
Output feature map 80 x 45 x 512

Output feature map 40 x 23 x 1024



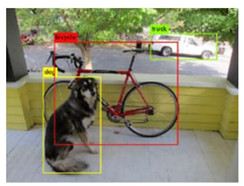
Copyright © 2023

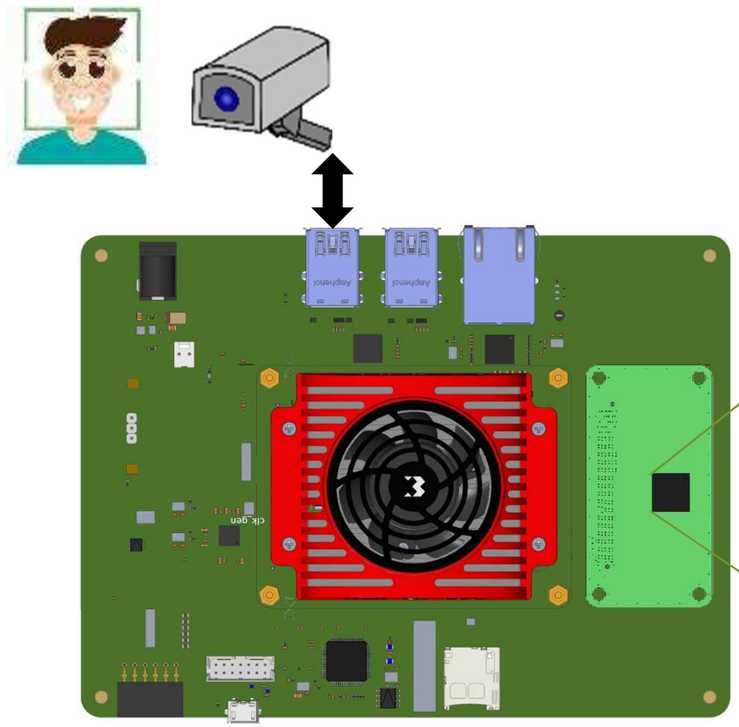
NeuroCorgi circuit



Copyright © 2023

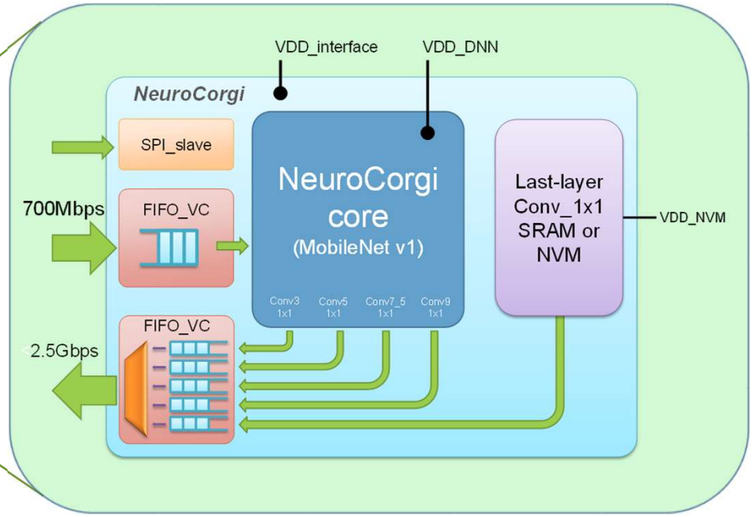
NueroCorgi demonstrator





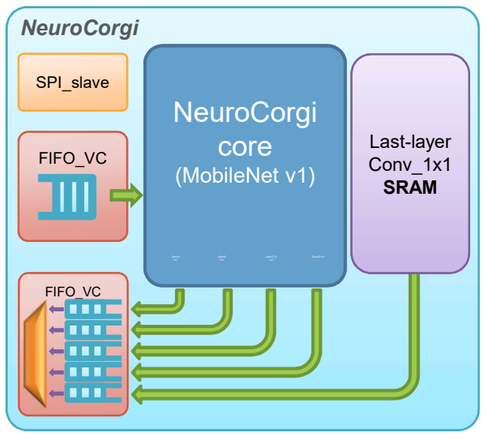
FPGA board used to:

- Manage interfaces (USB camera, ETH)
- Compute top CNN layers (e.g. object detection)
- Power management and measure

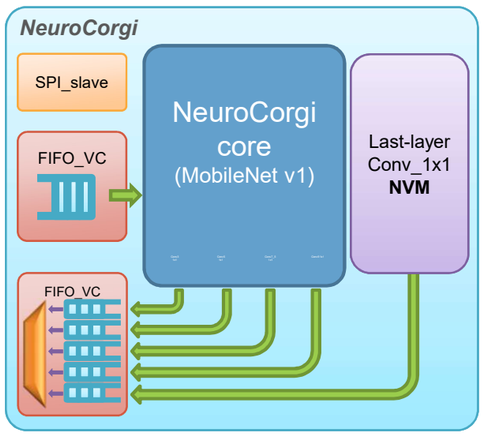


Copyright © 2023

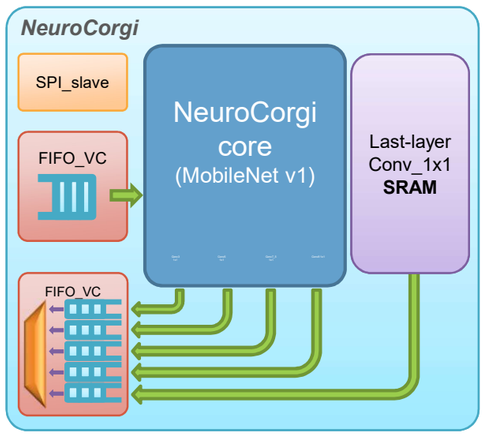
NeuroCorgi implementations



ImageNet database
Last Layer: SRAM



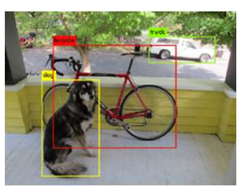
ImageNet database
Last Layer: NVM



COCO database
Last Layer: SRAM

Classification and segmentation tasks

Object detection tasks



Copyright © 2023

Digital Farming

UC2.1: Autonomous Weeding System

Description:

- Crops and weeds detection
- Intra-row weeding
- Mechanically: alternative to chemical weeding
- Autonomous: limiting human intervention

Challenges:

- Computation in real-time
- High precision needed to differentiate crops and weeds

Positioning vs State-of-the-art

- To date, for most crops, only inter-row mechanized/autonomous weeding solutions exists

Partners: Bordeaux-INP, CEA and STGNB

UC2.2: Tomato pests and diseases forecast

Description: Pest and disease detection model for the tomato agriculture industry.

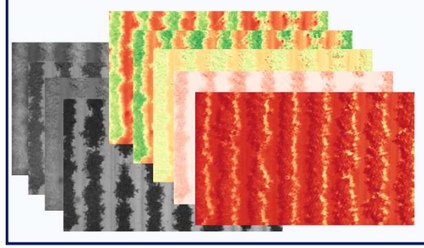
Challenges:

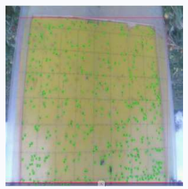
- Collecting enough and good quality data
- Time-series analysis for forecasting
- Model selection and development for edge devices

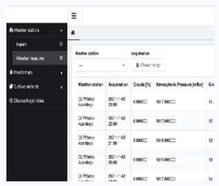
Positioning vs State-of-the-art

- State-of-the-art solutions do not resort to image analysis with ANNs, which produce many false positive events.

Partners: Inov, CCTI, Italagro, TPRO-Tech., CEA, STGNB

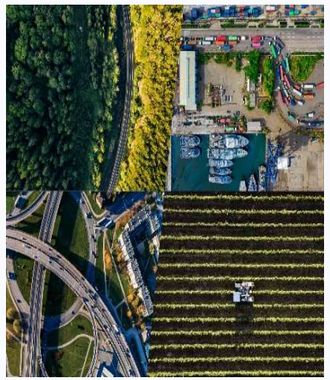






Copyright © 2023

Transport and Smart Mobility



UC3.1: Drones/USV

Description: detection, classification and segmentation of high-altitude images using either ANN, SNN or hybrid technology

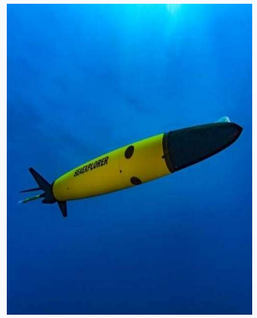
Challenges:

- Real time computation
- High resolution inputs
- Power consumption

Positioning vs State-of-the-Art:

- Existing solutions are not compatible with drone constraints

Partners: Thales, CEA, STGNB



UC3.2: Underwater Acoustic Signal Classification

Description: The ocean soundscape is a continuously changing mosaic of sounds that originate from various sources. This is of primary interest to recognize in real time the components of the soundscape. Study on marine mammals classification.

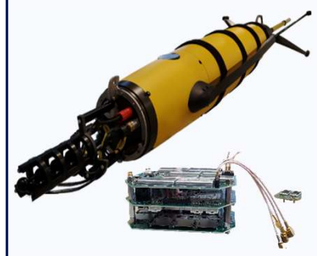
Challenges:

- Real time computation
- Low power

Positioning vs State-of-the-Art:

- Long-term monitoring
- Real time communication with shore

Partners: ALSEAMAR, CEA, STGNB, Synsense

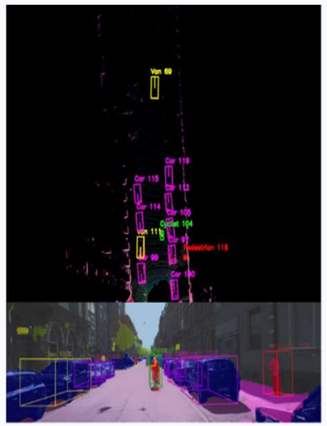


THALES
Building a future we can all trust

ALSEAMAR
ALCEN

Copyright © 2023

Transport and Smart Mobility



Partners: Valeo, CEA, STGNB, UZH

UC3.3: 3D Object Detection and Classification of Road Users based on LiDAR and camera

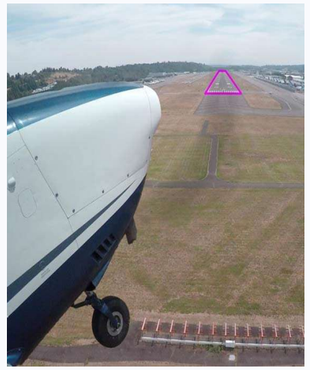
Description: Object detection on lidar point clouds that will be fused with camera semantic image data implemented on ANDANTE Platform

Challenge:

- Real time computation with received sensor data (bandwidth bottlenecks)
- Scaling to handle input of multiple sensors

Positioning vs State-of-the-Art:

- No fusion of both sensors/sensor data yet done on neuromorphic hardware



Partners: BR&T-E, Gradiant, TVES, CARTO

UC 3.4: Robust Autonomous Landing

Description: Four critical functionalities are considered: 1) image-based runway relative localization for navigation, 2) image registration for navigation, 3) foreign object detection on runway, 4) robust communications.

Challenges:

- Real time computation
- Adaptation of large networks to efficient hardware without sacrificing performance levels
- Learning on the edge

Positioning vs State-of-the-Art:

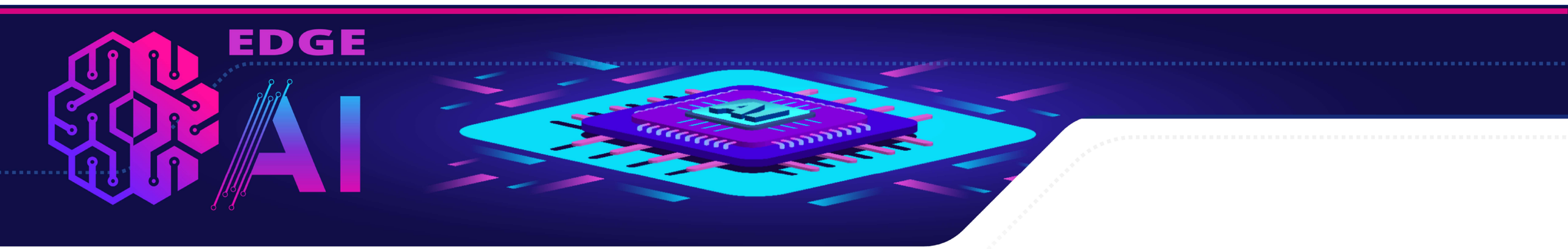
- Many smaller aircraft cannot permit energy cost of large number of conventional AI algorithms in standard hardware, which on the other hand, are necessary to enable autonomous operations.

Copyright © 2023

Conclusions

- NeuroCorgi leverages on a fixed-topology with fixed weighs to meet the energy and latency requirements
- Main pillars are ultra-low power consumption and ultra-low latency
- NeuroCorgi can compute HD images at 30FPS
- Energy and latency estimations are very promising. Circuit measure coming soon!
- Six use cases will use NeuroCorgi in the domains of Digital Farming and Transport and Smart Mobility

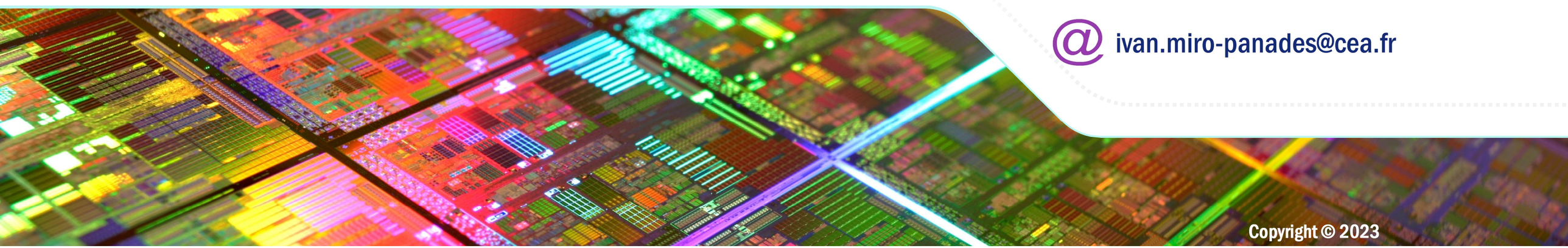
Copyright © 2023



Thank You

For your attention

@ ivan.miro-panades@cea.fr



Copyright © 2023