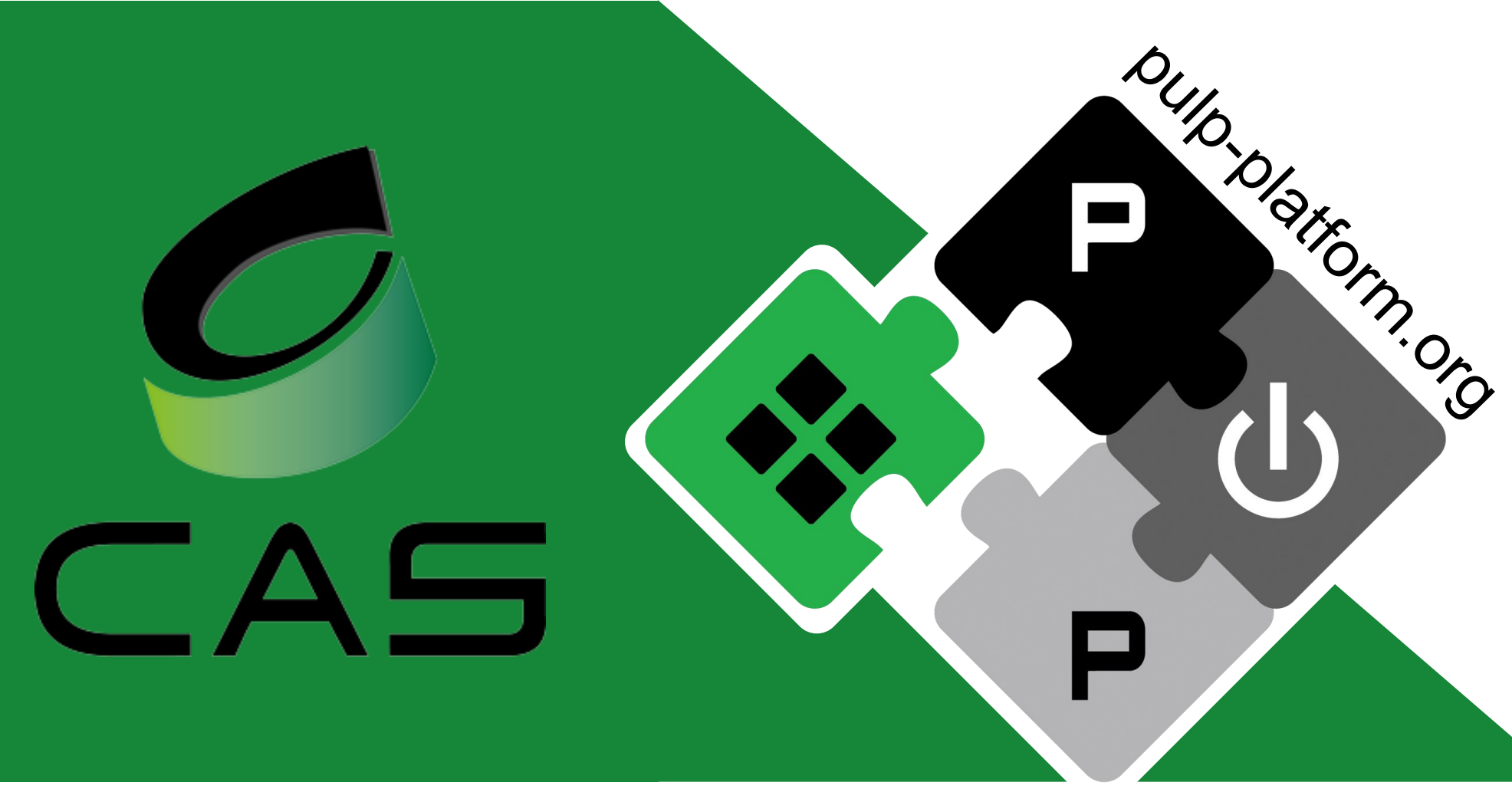


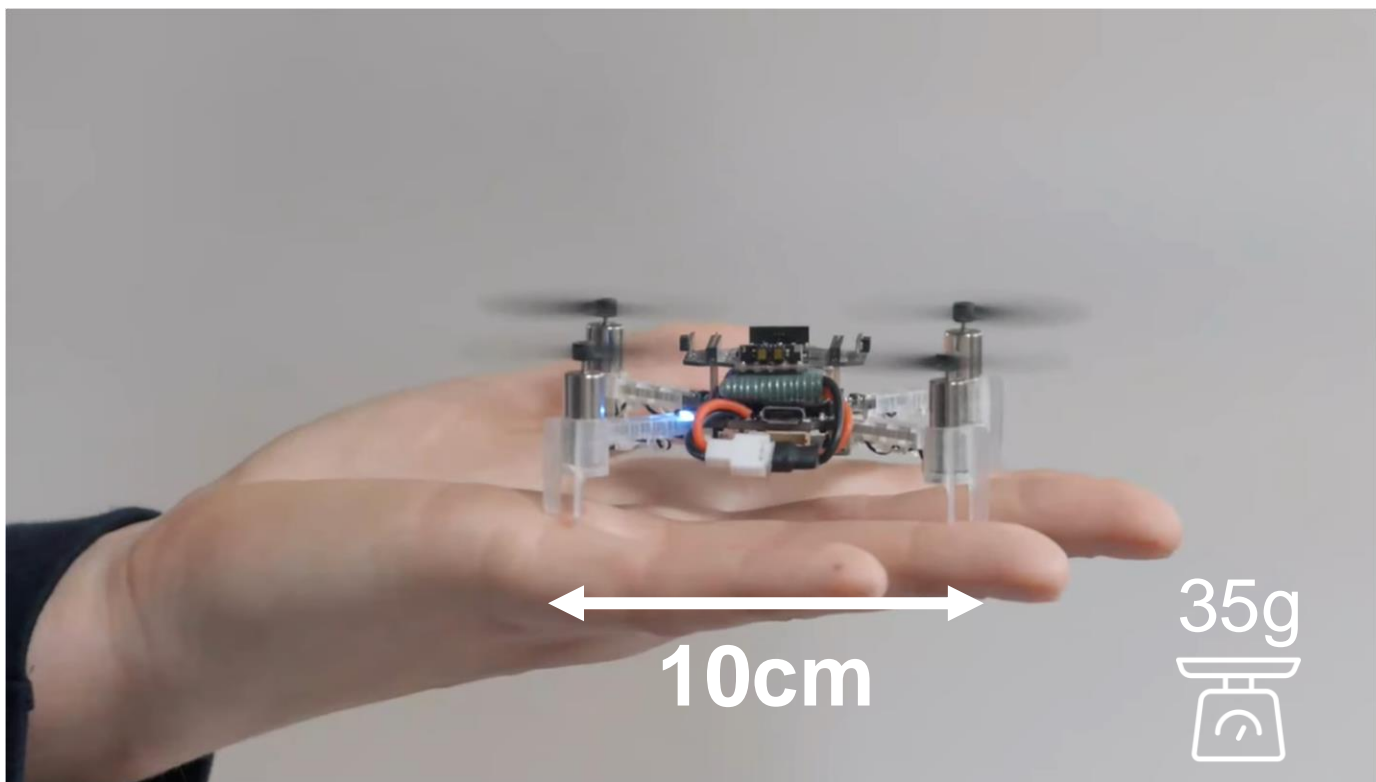
Event-based perception on autonomous nano-drones



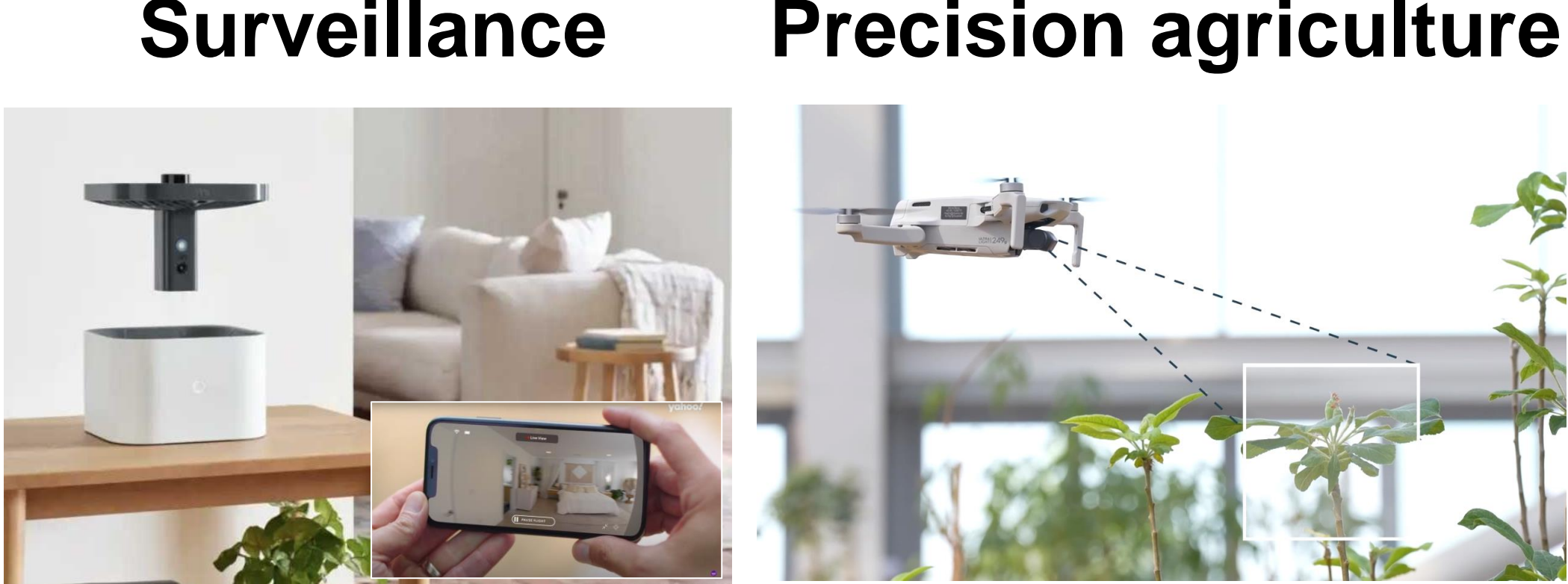
L. Lamberti, V. Kartsch, A. Di Mauro, D. Palossi, L. Benini



Nano-sized drones



Applications



Event-based vision

Camera	Traditional	Event-based
Dynamic range	60dBa	140dB
Temporal resolution	>10ms	~1µs
Motion Blur	High	low

Useful for high-speed and extreme light conditions

Nano-sized UAVs constraints

<10cm

Small form factor

<15g

Limited payload

<100mW

Limited computing power budget

<1MB

Limited on-chip memory

Requirements

Accurate perception

Real-time operation

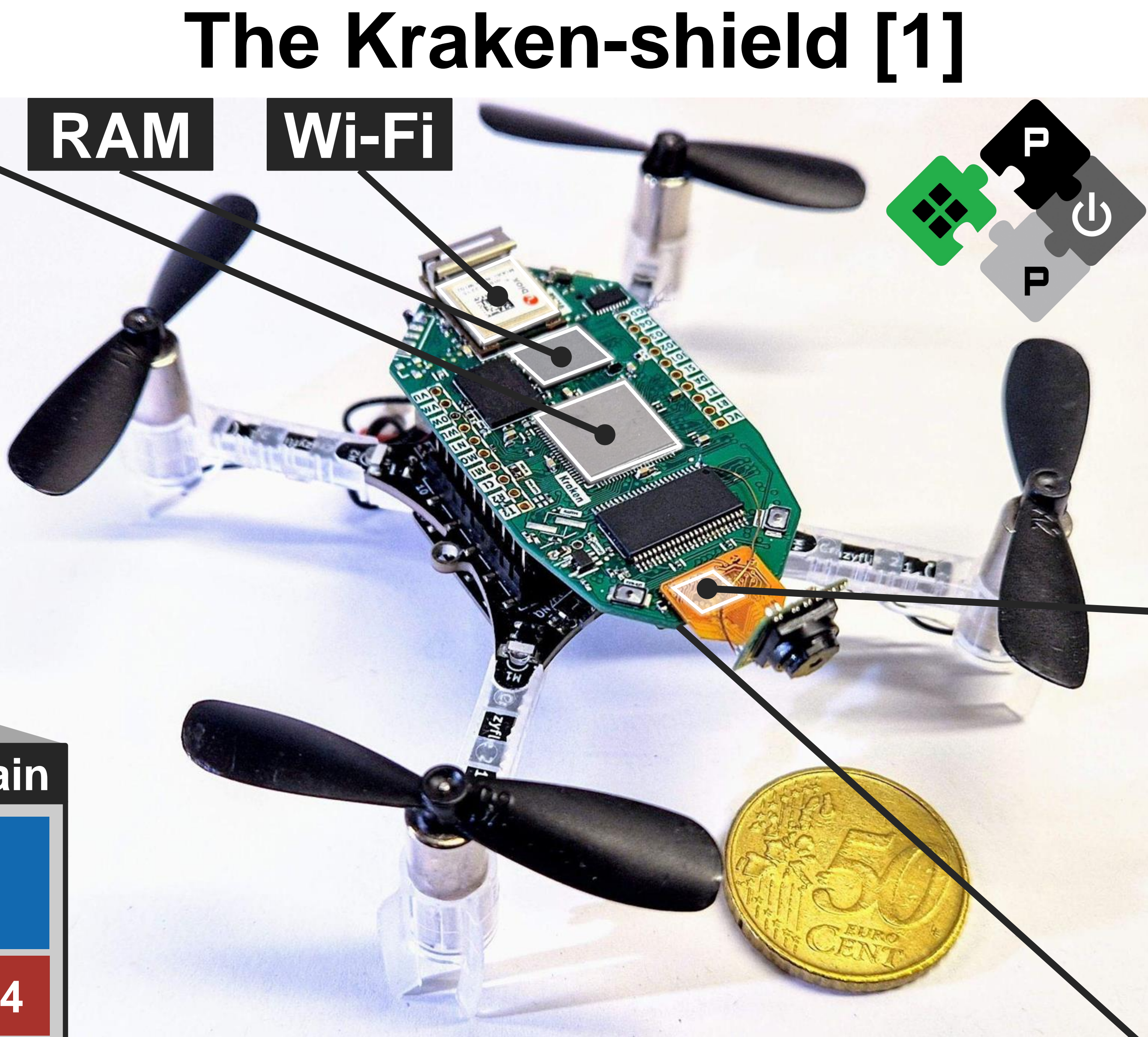
Event-based perception on autonomous nano-drones

Kraken SoC

ETH zürich
KRAKEN
The P Edition
Alfio Di Mauro
Moritz Scherer
Arpan Prasad
Tim Fischer
Oscar Castaneda
Manuel Eggmann
Matteo Spillanzani
Georg Rutishauser

SoC domain		Cluster domain			
CPI	L2 1MB	L1 128kB			
I2C					
SPI	Fabric Ctrl (core)	1	2	3	4
DVSI		5	6	7	8
...	FPU's	FPU's			
SNE domain		CUTIE domain			
SNE		CUTIE			

Legenda: Core (red), Memory (blue), Acceler. (orange), Periph (purple)



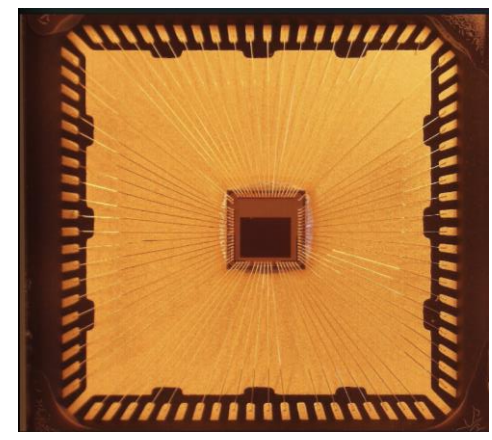
Domain	Max Freq
SoC	330 MHz
Cluster	330 MHz
SNE	220 MHz
CUTIE	330 MHz

Kraken SoC [2]:

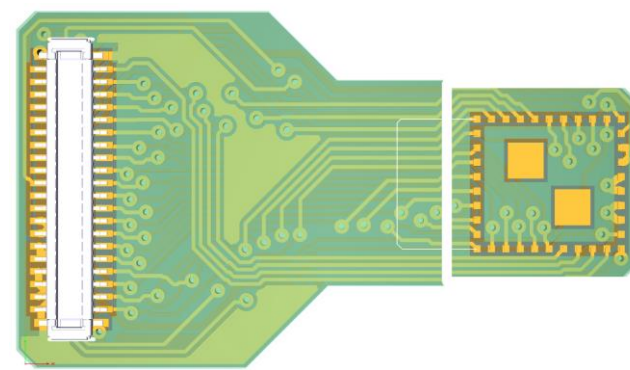
- DVSI: event-camera interface
- SNE: spiking NN accelerator
- CUTIE: ternary NN accelerator
- VDD: 0.55 -- 0.9V

Event-based camera

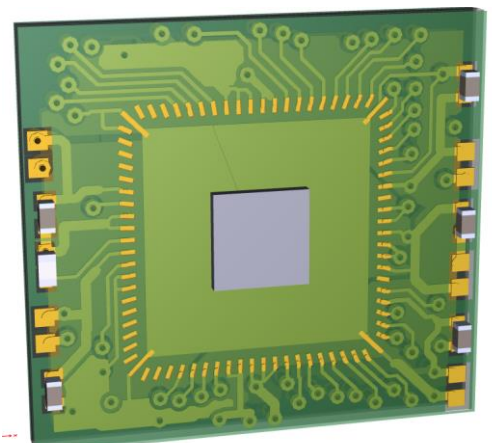
IniVation DVS132



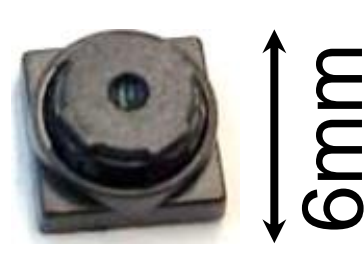
Flex cable



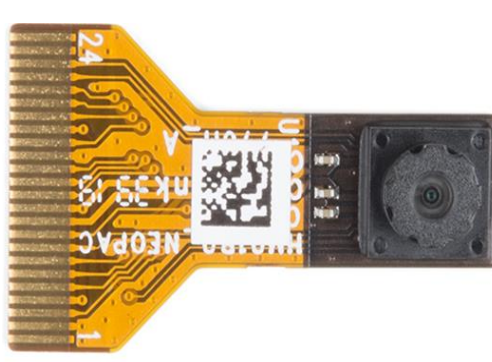
Die PCB



M4 Lens



RGB camera



DVS & frame-based cameras → real-time multi-modal perception on a nano-UAV

Events

Frames

Three tasks mapped on the SoC

SoC Domain	NN	Task	Inf/s	µJ/inf	Power (mW)	Freq (MHz)
SNE	Spiking	Depth estimation	1.2k	18	98	220
CUTIE	Ternary	Classification	10k	6	110	330
8-core cluster	Conv.	Autonomous navigation	221	750	165	300

Total power envelope: 373mW



[1] V. Potocnik et al., "Circuits and Systems for Embodied AI: Exploring w/ Multi-Modal Perception for Nano-UAVs on the Kraken Shield." ESSERC, 2024

[2] A. Di Mauro et al. "Kraken: A Direct Event/frame-based Multi-sensor Fusion SoC for Ultra-efficient Visual Processing in Nano-UAVs." Hot chips, 2022.