



SAR missions need drones with more autonomy !

- Why ? To operate in unstructured and hostile environments during **many hours over a wide area**
 - no (stable) network access + no GNSS-based positioning,
 - excessive energy cost of a live video feed to a human operator,
 - one drone = one operator : too limiting !
- How ? With **smart artificial vision**
 - Simultaneous Localization And Mapping (SLAM) and obstacle-avoidance algorithms,
 - best in class : **Deep Neural Networks (DNN)** .
- But ? **The energy bottleneck : need for efficiency !**
 - heavy processing requires lots of energy while resources are strongly limited in embedded systems !

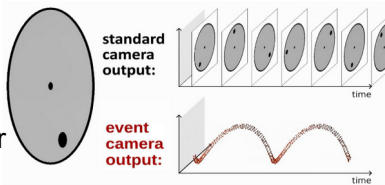


Energy-efficient low-latency sensors : event cameras

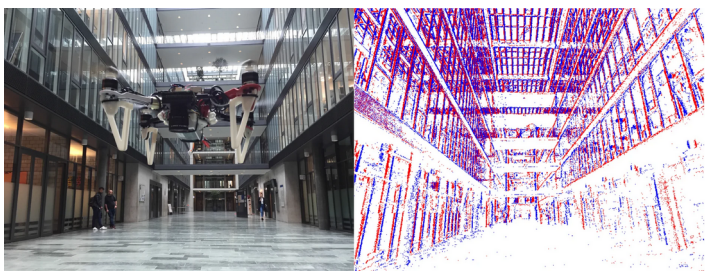
- **Dynamic Vision Sensor**
 - 1 pixel = 1 sensor of **intensity change** (+/-1).
 - An **asynchronous** event : triggered pixel position + timestamp.
 - **Tens of micro-second latency for a few mW.**
 - **High dynamic range** (90-120 dB vs. 50-80 for frame camera) and **no blur.**
- **Binary, sparse, asynchronous information :**
 - How to process it with neural networks to extract information for drone navigation ?
 - Is it hardware-friendly ?



DVXplorer Mini
(21g (pl.) / 46g (Al))
without lens,
640x480 res)



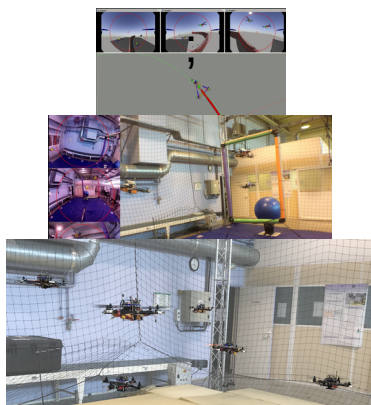
From <http://rpg.ifi.uzh.ch/docs/scaramuzza/>.
Video by University of Zürich, Robotics and Perception Group



A conventional camera picture vs. a picture constructed by buffering the outputs of an event camera (on the right) of the same building. The latter reports changes in brightness for each pixel (photo by University of Zürich).

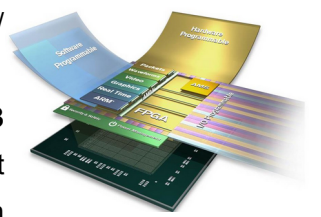
A novel drone control to design, test and explore !

- Demonstrate the benefits of combining event cameras and custom DNN processing on FPGA to improve reactivity and energy consumption of autonomous navigation techniques for a fleet of SAR drones :
 - design of a **new platform** with an adapted control and **simulation** with HW in the loop (in Gazebo),
 - **real-world experiments.**
- Give **access to an open platform** for further experiments with partners.

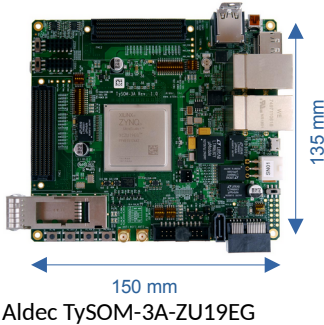


Energy-efficient DNN co-processors : custom DNNs on SoC/FPGA

- **Reconfigurable logic with hard-wired interfacing / processing / controlling units**
 - Same job as embedded GPUs but with **1/2-1/3 of the energy** (2018 Low Power Object Detection Challenge for UAV Applications, 55th DAC).
 - Spiking Neural Networks on neuromorphic chips favored by many researchers, but what can be used on **FPGA** ?
 - **Binary events + sparse information.**
 - Our choice : **jointly design algorithms, neural networks and processors** so that the choice of DNN, hardware, sparsity and quantization jointly meet the operational constraints of drones.



Xilinx System on Chip



Aldec TySOM-3A-ZU19EG

Steps toward a new open drone platform

