Hardware-based A.I. for adaptive sensing and point-of-care health monitoring

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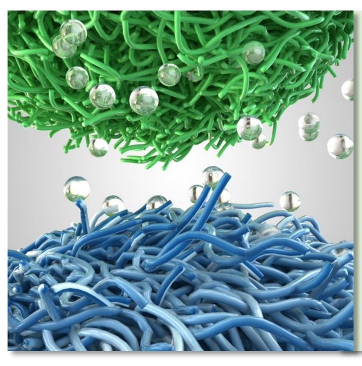
Organic neuromorphic engineering



- Energy-efficient parallel computing
- Autonomous and trainable arrays
- Dedicated and local processing
- Direct sensor input

Neuromorphic engineering aims to mimic the **efficiency of the brain** with dedicated hardware for artificial intelligence applications and direct coupling with sensors.

Organic materials have recently emerged as building blocks of neural processing [1] and can emulate brain-like functionality at the device level [2]. The excellent characteristics of organic electronic materials, such as low-energy operation and tunability, allows these materials to be used as a first step towards **efficient neuromorphic computing** systems [3].

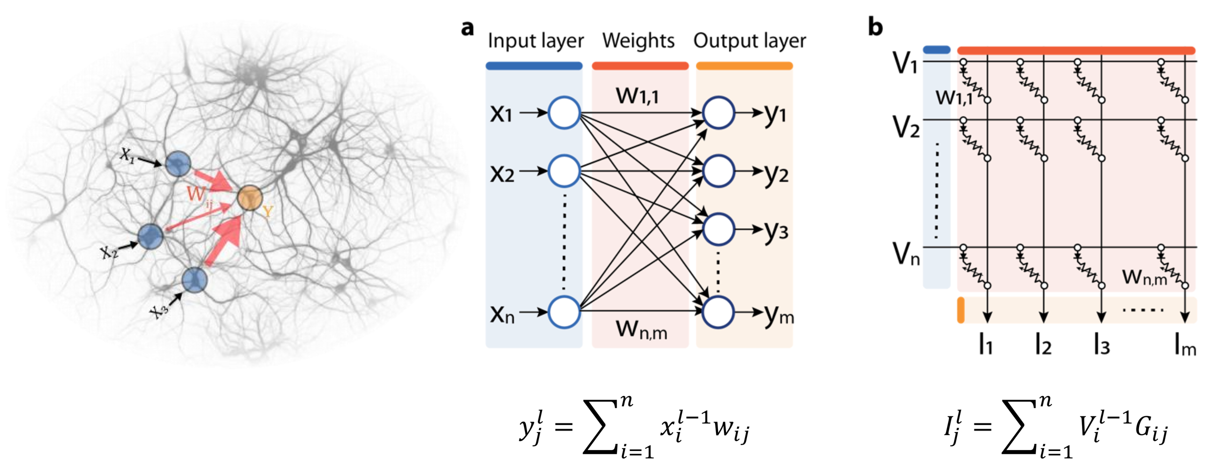


Figure 1: Brain-inspired neural network where the connection between the input (x) and the output (y) is represented by the synaptic strength (weight). Schematic (a) and (b) illustrate the software and hardware based network, respectively.

The conductivity of an **electrochemical neuromorphic organic device (ENODe)** can be tuned in a **non-volatile** way such that it can operate as the weight in the hardware based neuromorphic array.

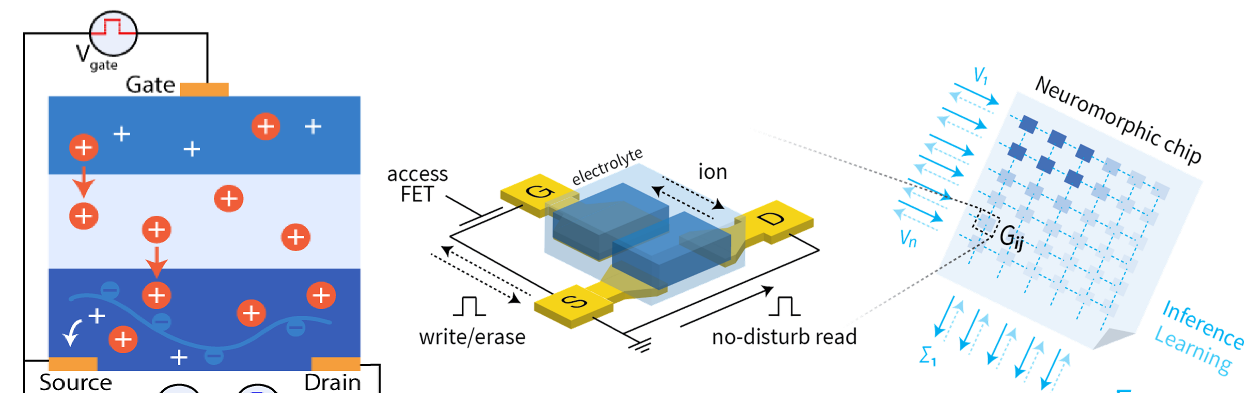


Figure 2: Schematic of the operating principle of an ENODe as well as the integration of an ENODe in an array.

These organic devices show **low energy operation** as well as a **wide range of stable states**

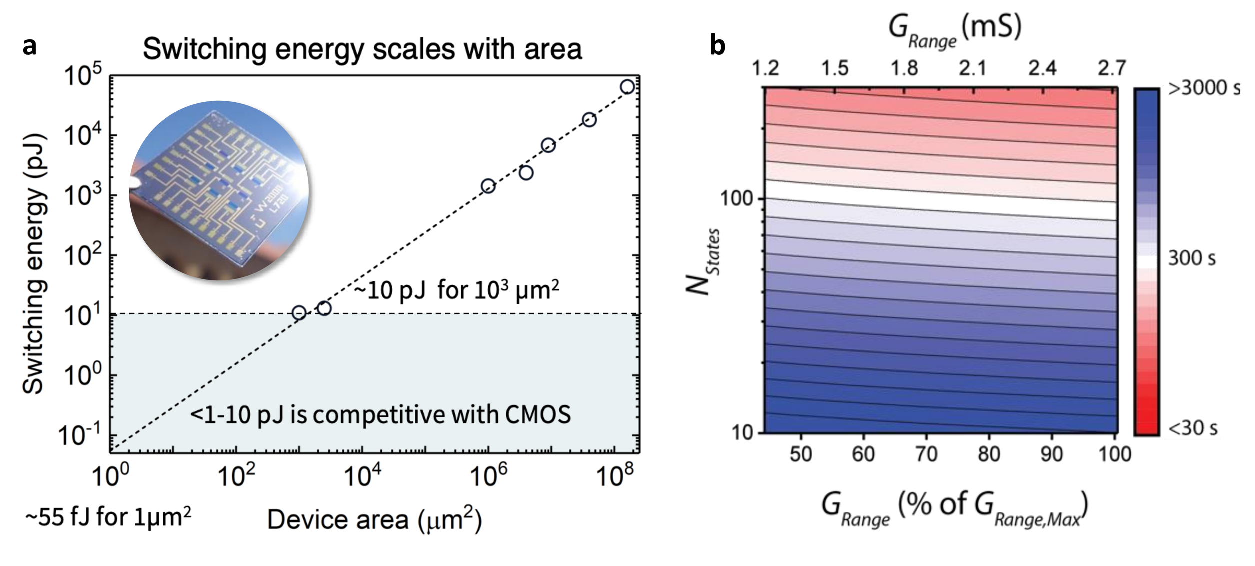


Figure 3: (a) Experimental result of the switching energy as a function of the device area and (b) the number of stable states vs the conductivity range [4].

Bioelectronics and sensing

- Smart (bio)sensing
- Hybrid neuromorphic memory
- Interfacing with biology
- Adaptive prosthetics

Recent studies have demonstrated a great biocompatibility of neuromorphic devices directly interfacing to biology.

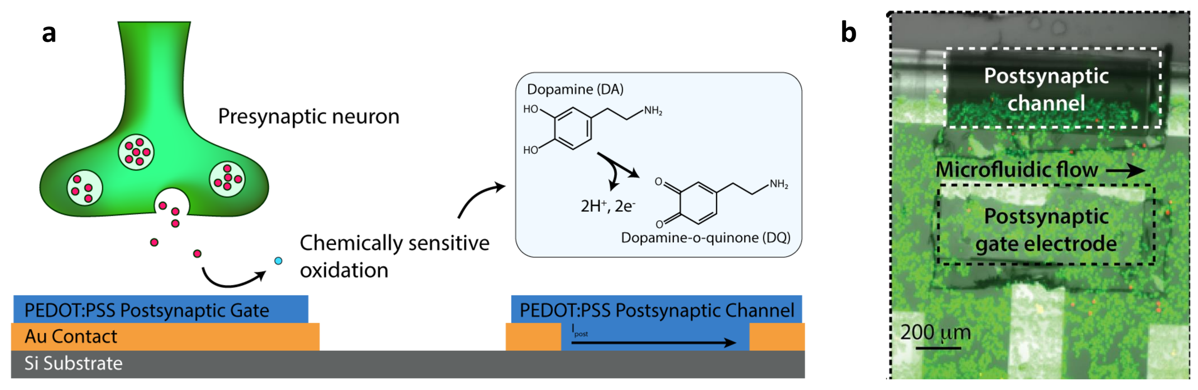


Figure 4: (a) Schematic of a biohybrid device able to detect the chemical activity of neuronal cell demonstrating both short and long term plasticity. (b) fluorescence image of PC-12 neuronal cells coupled to a single device.

Due to the great biocompatibility, local processing in the body and smart adaptable devices can be envisioned. With multiple sensor inputs feeding the neural network, closed-loop locally controlled systems be placed inside the body.

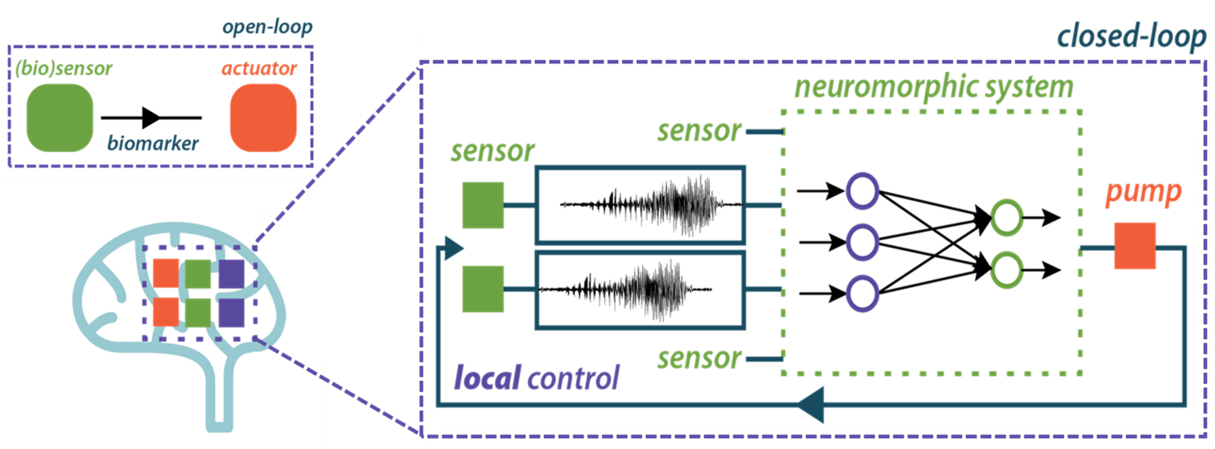
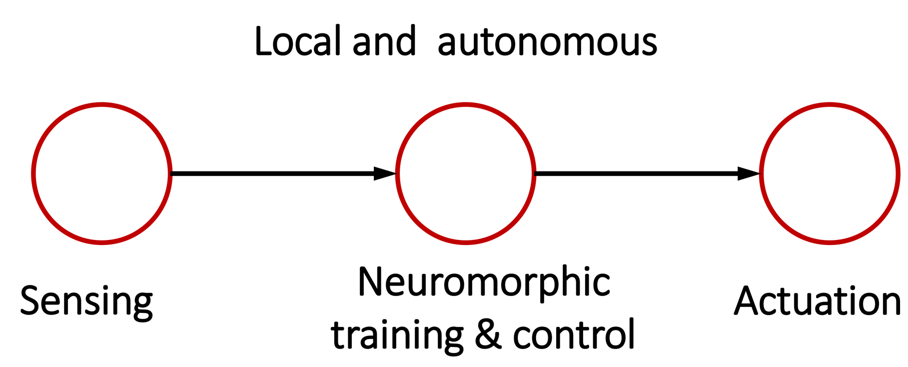


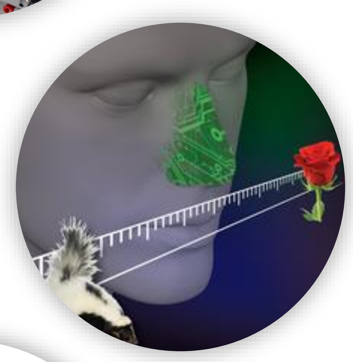
Figure 5: Illustration of an open- vs closed-loop system [5].

Smart Robotics NEW

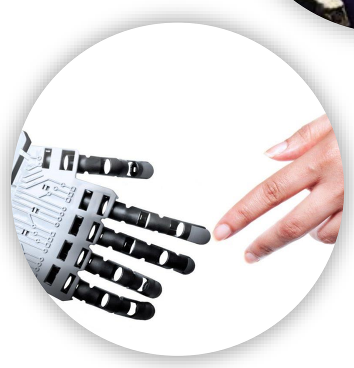
- Smart systems
- Trainable adaptable devices
- Brain-Machine interfaces



Smart robotics
Local autonomous path planning



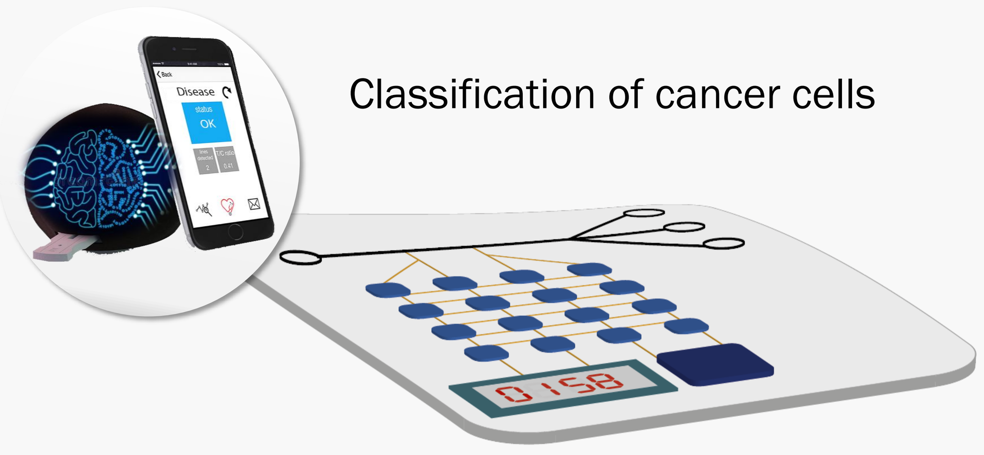
E-nose
Local autonomous trainable



Soft robotics
Interfacing with living systems

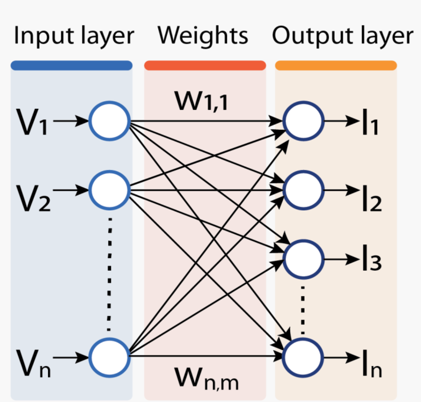
Smart point-of-care system | Biomorphic

Artificial Intelligence	*for* Health Care	**BIOMORPHIC**
Machine Learning	Train on data *e.g. images*	Train on data *microfluidic sensors*
Neural Networks	Finding patterns *e.g. detection of skin cancer*	Finding patterns *recognizing cells*
Energy in-efficient *i.e. sequential computing*	**Need for powerful PC** *non point-of-care*	**On chip** *point-of-care*

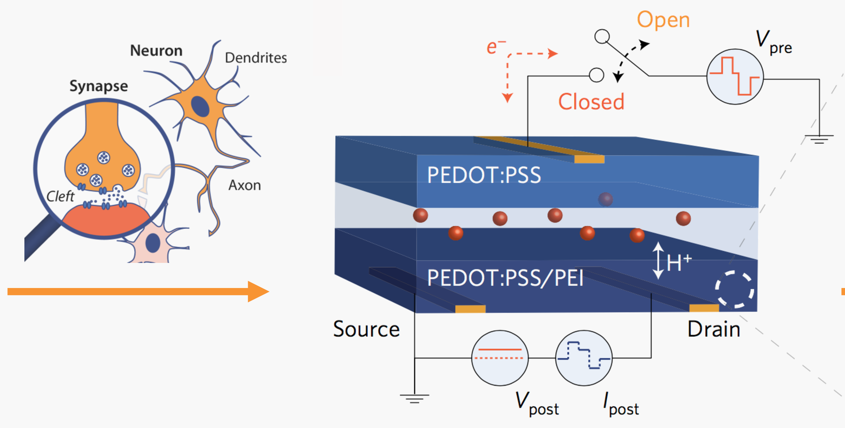


Classification of cancer cells

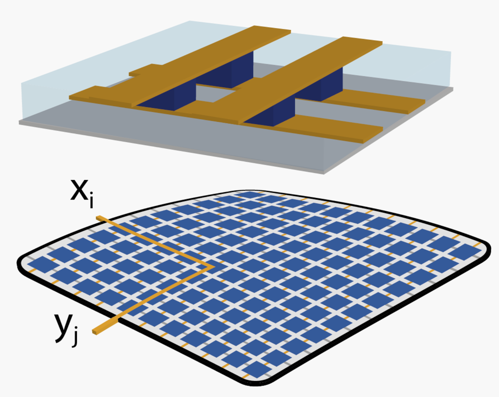
1 | Neural network



2 | Single synapse



3 | Crossbar array of synapses



1. van de Burgt et al. Nature Materials, 2017
2. Gkoupidenis et al. Advanced Materials, 2015
3. van de Burgt et al. Nature Electronics, 2018
4. Keene et. al. Adv Electr. Mater, 2018
5. ERW van Doremaele et al. Journal of Materials Chemistry C, 2019

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