Quality-energy trade-off in bio-inspired electronic systems

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Applications are demanding new approaches to electronic systems. The concept of aiming for the best performance in terms of speed and dimensions, which drove the electronic design in the last decades, is no longer valid. Nowadays, electronic systems may face very different scenarios, where sometimes speed is of little importance, whereas power consumption and reliability are key. It is essential to find new approaches that must have an impact at the system level, not on parts of the system but on its global structure: the optimization is done as a consequence of the choices related to how single devices are working, as well as how they interact and exchange information. The two levels (system and device) are strictly related, and design choices have to be made looking at the system as a global entity to be optimized.

The space of system design solutions is almost infinite and important efforts are underway to provide system designers with an arsenal of automated tools for architectural decisions and the implementation strategies. But for optimizing the aforementioned aspects, there exists a strategic choice of the system level paradigm that will drive all of the subsequent design choices. One possibly strategy is to take inspiration from biological systems, merging several techniques developed in recent years and exploiting them to reach the best trade-off between performance and power consumption [1]. Some useful design paradigms are: *the event-driven scheme*, applying the concept of need-based computation, where the system must react to events; *neuromorphic architecture*, relying on the spike-based generation of signals and information; and *bio-inspired electronic systems*, applying biological paradigms to system optimization.

As first consequence, it is possible to implement systems that work with digital signals acting on analog information, no longer based on amplitude or bits, but on a time-based approach, as reported for specific applications in [2] and [3].

1. M. Alioto, "Designing (relatively) reliable systems with (highly) unreliable components", presented at *14th IEEE NewCAS Conf.* (2016).
2. P. M. Ros, M. Crepaldi, C. Bartolozzi, and D. Demarchi, "A hybrid quasi-digital/neuromorphic architecture for tactile sensing in humanoid robots", *Proc. 6th IEEE Intern. Workshop Adv. Sensors Interfaces (IWASI)* (2015), pp. 126–130.
3. S. Sapienza, C. Crepaldi, P. M. Ros, A. Bonanno, and D. Demarchi, "On integration and validation of a very low complexity ATC UWB system for muscle force transmission", *IEEE Trans. Biomed. Circ. Systems*, **10**, 497 (2016).