Reservoir Computing *in materio* with LEDs

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Reservoir Computing (RC) began as an efficient technique for training recurrent neural networks and as a computational model for neural microcircuits. More recently, new unconventional reservoir computers have emerged, inspired by examples such as the bucket of water reservoir [2]. Systems include photonic and optoelectronic reservoirs, with performances close to state-of-art techniques in machine learning [3]. Applying the RC framework to physical systems has become attractive due to being conceptually simple to train and implement.

We have shown that the RC framework transfers to complex substrates, and that performance can increase significantly when we control and manipulate input-output mappings and external perturbation through computer-controlled evolution [1]. That work is largely based on random formations of carbon nanotubes in a dielectric polymer. However, the possible scope of conventional and unconventional substrates is unknown, and combining materials with different characteristics has not yet been demonstrated.

To investigate this scope we have implemented a new example of the hardware-based reservoir methodology. We have two new types of reservoirs based on simple-to-manufacture printed circuit boards with surface-mount HSMG-C280 Light Emitting Diodes (LEDs) and 180R resistors. The first is an array of 64 LEDs in parallel, connected by copper tracks via a single ground. Results show that unconstrained computer-controlled evolution can exploit the net effect of variations in components (resistors and diodes) to form a single reservoir competitive to previous findings. The second is four separate 16-LED boards that combine to form a single reservoir. Results demonstrate that outputs of individual networks (LED arrays) can combine to produce results that surpass a single network, forming a simple, modular reservoir system.

References

1. M. Dale, S. Stepney, J. F. Miller, and M. Trefzer. Reservoir computing in materio: An evaluation of configuration through evolution. In *2016 IEEE Symposium Series on Computational Intelligence (SSCI)*, pages 1–8, Dec 2016.
2. C. Fernando and S. Sojakka. Pattern recognition in a bucket. In *Advances in Artificial Life*, pages 588–597. Springer, 2003.
3. L. Larger, A. Baylón-Fuentes, R. Martinenghi, V. S. Udaltsov, Y. K. Chembo, and M. Jacquot. High-speed photonic reservoir computing using a time-delay-based architecture: Million words per second classification. *Phys. Rev. X*, 7:011015, Feb 2017.