Extendible Hardware Platform for Reservoir Computing *in materio*

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We have shown that the theoretical framework of Reservoir Computing (RC) can be applied to *in materio* computing as a computational layer able to extract exploitable information from physical substrates [1]. The RC framework provides a computational model for our current black-box system, and a simple training mechanism that produces a task-specific readout layer, translating material behaviour into a physical task solution. However, a physical performance limitation of our current system is the number of interfacing electrodes to the material. We hypothesise that the materials under investigation contain different *resolutions* (nano- to millimetre scale) of interesting computational activity, and the sampling effect of accessing only a subset of spatial states may result in a quantisation/smoothing effect at the output. We therefore further surmise that adding more electrodes may counter this effect and sample a larger state space of the material's behaviour, which, in addition, could improve training as more information is provided to the readout.

To this end, we have designed and built a new hardware platform that increases the previous 12 electrode system to a 64 multi-purpose electrode system. We have also designed and fabricated electrode array slides for housing materials, based on low-cost printed circuit boards (PCB) instead of the previously-employed gold photo-lithography glass slides. These slides are connected via a new switch board to the PC-based input and output Data Acquisition Cards. We have several options for external housings for these slides, including one variant that can accommodate four separate 16-electrode slides in parallel, allowing us to study coupled reservoirs.

We have some initial results from this scaled system, and how it compares to the smaller electrode array system. In particular, we have developed a new programming schema enabling us to apply both configuration/control inputs – perturbing the material into a "configured state" – and a task input-weighting mechanism, something previously infeasible on the old system. This extra flexibility allows improved performance.

References

1. M. Dale, J. F. Miller, S. Stepney, and M. A. Trefzer. Evolving carbon nanotube reservoir computers. In *Unconventional Computation and Natural Computation: 15th International Conference, UCNC 2016, Manchester, UK, July 11-15, 2016*, pages 49–61. Springer International Publishing, 2016.