Going DEEPER: Artificial Evolution *in materio*

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We discuss the view that material systems become more evolvable when there is a rich and varied embedded physics that can be exploited by the evolutionary process. In the research field of Evolvable Hardware researchers are using artificial evolution to construct electronic or electrical circuits. Generally they employ programmable circuits called Field Programmable Gate Arrays (FPGA) for digital circuits and purpose built reconfigurable arrays of analog components often referred to as Field Programmable Analog Arrays (FPAA). Some researchers are using computers to 'wire-up' arrays of reed switches to perform as novel antennas. When actual circuits (rather than simulations) are evolved and tested the process is called intrinsic evolution. The FPGAs are designed as digitally reconfigurable devices: clean response, sharpness of switching signals. We argue that it is improbable that devices that man has designed for conventional electronic design are the most suitable platform for intrinsic evolution. One of the most outstanding results in this field was the discovery by Thompson [1] that when certain FPGAs were subjected to a process of intrinsic evolution (to create a square-wave frequency discriminator circuit) the evolved circuit was exploiting the resident physics of the device.

Natural evolution has been building biological systems of exquisite complexity for millenia. It has been doing this at a molecular level. A research project called DEEPER aims to use artificial evolution to discover its own problem specific relevance criteria and to create electrical/electronic "circuits" at a molecular level using novel materials not normally associated with electronic circuits. Essentially the project is attempting to use artificial intrinsic evolution to configure materials directly for some useful purpose and it aims to see if artificial evolution can create entirely new technologies i.e. transistor-less circuits for sophisticated technological applications. Such direct physical exploitation may be useful in the construction of novel sensors or novel information processing systems. In the latter case the materials that are expected to be evolvable are likely to be mesotropic (existing in two or more phases) and whose physical properties can be controlled by a small applied voltage. We discuss some practical suggestions and candidate materials.

[1] A. Thompson. "An evolved circuit, intrinsic in silicon, entwined with physics", in T. Higuch, M. Iwata, W. Liu (eds.), Proc. of The 1st Int. Conf. on Evolvable Systems: From Biology to Hardware, LNCS, vol. 1259, Springer-Verlag, pp. 390 - 405, 1997