Evolving Artificial Cell Signaling Networks

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Cell Signaling networks (CSNs) are bio-chemical systems of interacting molecules in cells. Typically, these systems take as inputs chemical signals generated within the cell or communicated from outside. These trigger a cascade of chemical reactions that result in changes of the state of the cell and (or) generate some chemical output, such as prokaryotic chemotaxis or coordination of cellular division.

Realising (and evolving) Artificial Cell Signaling Networks (ACSNs) may provide new ways to design computer systems for a variety of application areas. We are investigating the use of ACSNs to implement computation, signal processing and (or) control functionality. We review some of the the research issues which this raises:

- As a "computational" device, a CSN is most naturally compared to a traditional *analog* computer. There may be applications where a molecular level analog computer, in the form of a CSN, may have distinct advantages. CSNs may offer capabilities of high speed and small size that cannot be realised with solid state electronic technology. More critically, where it is required to interface computation with chemical interaction, a CSN may bypass difficult stages of signal transduction that would otherwise be required. This could have direct application in so-called "smart drugs" and other bio-medical interventions.

- Evolutionary Algorithms are non-deterministic search and optimisation algorithms inspired by the principles of neo-Darwinism. Such techniques are relevant to the study of ACSNs because: the complex, and unpredictable, interactions between different components of CSNs, make it very difficult to design them "by hand" to meet specific performance objectives. However, natural evolution shows that in suitable circumstances, effective CSNs functionality can be achieved through evolutionary processes.

- "Crosstalk" phenomena happen when signals from different pathways become mixed together. This arises very naturally in CSNs due to the fact that the molecules from all pathways may share the same physical reaction space. In traditional communications and signal processing engineering, crosstalk is regarded as a defect that therefore has the potential to cause system malfunction. This can also clearly be the case of crosstalk in CSNs. However, in the specific case of CSN's, crosstalk also has additional potential functionality, which may actually be constructive.

- It is also argued that key properties in biochemical networks are to be robust, this is so as to ensure their correct functioning. Such properties are highly desirable in dynamic engineered systems when subjected to internal and external uncertainty and perturbation.

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