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Abstract:

A Generic Modelling Framework for Complex Systems Synthesis.

Introduction.
This paper aims to show how a unified modelling framework for rapid prototyping and simulation based on Tunable Excitable Media, can empower a great range of interdisciplinary fields with the necessary tools to perform complex system research.

Excitable media is a collection of nodes where each node is linked to other nodes by a certain linkage scheme.
Each node transmit signals in the form of objects to its connections.
The signals arrive at their destination node where they are computed as the input to the node's kernel function.
The results from the node's kernel function are then redistributed back into the media.
This creates the basis for iterative systems with complex inter-promulgations,
and is as such an ideal architecture to run complex systems on.

The approach is to create a generic framework for kernel based stream computing,
on the Graphics Processing Unit (GPU). The Gpu of choice for the prototyping is the new gp-gpu from ATI
the Firestream 2u where the solution is coded in assembly
on the CTM abstraction layer which exposes the hardware directly.

Rationale. Currently a convergence towards solutions in the form of complex systems has emerged as ideal,
but implementationaly challenging solutions to some of the toughest scientific challenges of today.

This paper shows how models from these sciences converge in their parallel
implementations, and how generics in their architecture allow them to be modelled by a flexible unifying object api.

Examples:

Physics. Lattice Boltzmann (LBM).
Computational fluid dynamics and nanotechnology has during the last 10 years started to employ the
Lattice Boltzmann algorithm to model particle collisions and multiphase flow. The LBM method is very different from the traditional Navier-Stockes algorithm, the LBM model is an extended cellular automata approach based solely on particle-local collision rules, and can therefore be executed in fully parallel.
This algorithm is a perfect candidate to be modelled as a complex system and run on excitable media.

Neuroscience. Liquid State Machine.
Advanced models of the neural system regards the neural circuitry as complex systems, where equilibrium, stability, limit cycle attractor, and bifurcations becomes the language of though. One of the most advanced models of the cortex is the Liquid State Machine aka the cortical microcircuit model. This model works like a liquid and can modelled by extended cellular automata principles and be executed on excitable media.

Genetics. GRN. - Having solved the mystery of how DNA encodes proteins, one of the next big questions is how gene expression are controlled, E.g. What mechanism controls if a cell becomes a skin or a nail cell.
The system that controls this is called GRN : The Gene Regulatory Network. GRN is a complex system consisting of an mRna soup, that controls which proteins are to be synthesised. GRN can be modelled as a Random Boolean Network, an extended cellular automata approach, and be run on excitable media.

Molecular biology. Lattice protein folding. Real proteins in their all-atom detail are to computationally demanding to be folded on a single gpu. Lattice proteins, however, are simplified in two ways: the amino acids are modelled as single "beads" rather than modelling every atom, and the beads are restricted to a rigid cubic lattice.
This simplification allows them to fold to their energy minima in a time quick enough for simulation.

Artificial intelligence. Genetic Algorithms, Neural Networks, Self Organizing Maps, and Multi Agent Systems,
are all distributed methods that can be parallelized and encoded to run on excitable media.