**LUBBOCK PRESENTATION – October 2012 - Sergio Pissanetzky**

**1. Causality, symmetry, brain, evolution, DNA, and a new theory of Physics.**

**2.** I work on complex systems with a detailed dynamics, such as adaptive systems that learn from their environment and adjust their dynamics. Computers and robots also have a detailed dynamics. Too detailed for statistical or nonlinear methods.
I propose a theory from fundamental principles: causality, symmetry, least-action, thermodynamics.

**3. CAUSALITY**
Create a causal set model of the given system.
Causal sets come from sensors or senses, computer programs, equations.
Causal sets are executable. They can control actuators. Or motor nerves.
Rule of thumb: if you don't know how to build the model, then write a computer program about it
and convert the program to causal set format.

**4. SYMMETRY**
Causal sets have a partial order, and a symmetry.
Because they have symmetry, they also have conservation laws and conserved quantities.
To find them, we need the principle of least-action, because conserved quantities appear in
conservative physical systems, which follow least-action trajectories.

**5. LEAST-ACTION**
Define a state space with the elements of the set, an initial state, and a final state.
Causal chains in the causal set represent trajectories in state space.
But their number is enormously large. There is a combinatorial explosion !!!
Define a functional native to causal sets, equal to the length of the trajectory.
**Postulate:** The functional represents action in the dynamical system.
This functional was experimentally found. It is not heuristic, but observed. When minimized:
● the dimension of the state space is reduced and the combinatorial explosion is eliminated;
● the system becomes conservative: group-theoretical block systems become observable;
● the block systems are self-organized attractors;
● the block systems are causal sets themselves, iteration results in hierarchies.

**6. CENTRAL THEOREM**The conserved quantities are scale-free hierarchical networks of
group-theoretical block systems over the causal set. See example.

**7. THERMODYNAMICS**Minimizing the action also minimizes free energy and entropy in the system.
Entropy is a measure of uncertainty. Least entropy is least uncertainty.
There still remain multiple trajectories, which represent remaining uncertainty.
The block systems are certain, because they are invariant under the trajectories.

**8. VERIFICATION
Neuroscience
!!** • Length of dendritic trees must be minimum. Cuntz (June 2012) confirms 2/3 power law, optimally short, valid for all types of neurons, across species. Supersedes a previously accepted 4/3 power law.
**!!** • Scale-free hierarchical networks. Fuster (2005) observes networks of cognits in cortex/cognition.
• Action functional. Friston (2003) uses an energy functional to unify brain theories.
• Scale-free hierarchical networks. L. Lin (2006). Neural cliques.
**!!** • Determinism, unpredictability, deterministic chaos. Eagleman (22 Sep 2012): biology determines decisions, not free will.  **Biophysics
!!** • Susanne Still, Gavin Crooks (5 Oct 2012). Motor proteins. Profound connection between effective use of information and thermodynamic efficiency. Any system that keeps memory about its environment and operates with maximal energetic efficiency has to be predictive.
**Evolution**
**!!** • DNA. (Sept 2012) consists of hierarchical networks (ENCODE project, Nat. Human Genome Inst.).
• Action functional. Lerner (Aug 2012) proposed an action functional and minimum entropy trajectories.
**Artificial Intelligence**
• Jeff Hawkins, Dileep George (Numenta). Use scale-free hierarchical networks to model the neocortex.
**Computer Engineering**
**!!** • Scale-free hierarchical networks. Google patents, US Patent 8,254,699 (Aug 2012). Object recognition for the Internet of Things. Dimensionality reduction, feature vectors.
• Scale-free hierarchical networks. Object-oriented analysis and design. Classes, objects.

**Physics**
**!!** • A. Annila, T. Hartonen, T. Pernu. (Oct 19, 2012) Describe natural networks as actions, or energies in motion, emergence follows from the principle of least-action. Systems in evolution are described by least-time consumption of free energy. They got nearly everything I did except for the causal sets, the functional, and the physical foundation!
• My own computational experiments.

9. REFERENCE.
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Complexity 17(2): 19–38 (Nov. 2011).