Fitness in a change of era: Complex Adaptive Systems, Neocortex and a New Class of Information Processing Machines

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"We don't live in an era of change but in a change of era".
Edgar Morin.

Introduction: The purpose of this work is to look at current information processing performance and necessary evolution from a business and information system management standpoint, why it matters and why current research allows optimism. We will start with an overview of Complex Adaptive Systems and why they are cardinal for our purpose. Then, we will decipher what neuroscience and brain theory are telling us when it comes to mimicking the brain to improve machine intelligence. It will be easier then to compare how we behave, at brain, individual and collective levels vs. current architecture and capabilities of machines and network of machines. We will see that our existing and more importantly, our future needs are far from being met with the shortcomings of current information processing architecture. Last, we will talk about promising works that can meet expectations in making much better leverage of our own knowledge structures, the way we think, make decision and take action, and how we adapt our behaviors for better fitness.

Living species or social organizations behave like **complex adaptive systems** (CAS); sets of agents pursuing their own goals with their own representation of the world and who follow common rules for better fitness. CAS have inner properties that network of machines can acquire to reach self-organization and self-maintenance: this paper will go through these properties as a roadmap for a new class of information processing machine.

The Neocortex: this paper is built on the the assumption that the model of Vernon Mountcastle and the overarching framework of Jeff Hawkins are accurate. Then, we will describe how they think that cortical columns are the knowledge processing units of the neocortex, how it works and why it is of foremost importance when it comes to be inspired by nature to build intelligent machines. In particular, we will see that the neocortex is a predicting machine, that knowledge is movement based and how diversity and democracy are at work in our brain.

Brain to Machines: we'll go through the main differences between the two and especially, under the angles of embodiment, entropy management and homeostatic control and their consequences in terms of intelligent dispatch with hierarchy and sparsity, intensive knowledge of oneself and real time predictive management.

Current limitations of information processing machines and architecture:

Existing and near future needs exhibit the shortcomings of the current state of Information Processing Machines. We will focus on the most impactful: real time processing, control and maintenance, heterogeneity and oligopoly, security, cost and energy effectiveness and statistical learning.

Towards a new class of intelligent information processing machines:

The very same way convolutional neural networks outsmarted vector machines in object recognition from images in 2012, a new information processing framework would overcome all the limitations that we mentioned. Leverage CAS properties with an innovative and appropriate mathematical framework followed by proper implementation, is under way with what Prof. Mark Burgin and Prof. Rao Mikkilineni call **"autopoietic machines"**. First, we'll discuss the relevance of the DIKW (Data, Information, Knowledge, Wisdom) pyramid and why the KIME square (Knowledge, Information, Matter, Energy) is much more adequate and how it structures the problem to solve: finding a model of knowledge processing that can be applied to a network of network of machines, self-managed, self-organized to remain homeostatic. Then, we will go through the definition and articulation of the **Knowledge Structures Framework** and its components before assessing the various and profound consequences it begets. More specifically, we'll argue that an emergence of the model is the concept of digital gene in addition to the digital neuron to give rise to autopoietic machines. Then, we'll see that applications are manifold and beyond the infrastructure layer and we will go through some examples of what deep reasoning can lead to. We'll then conclude to open the discussion about autopoietic complex adaptive systems in an era of change, for information processing machines as well as for social organizations.

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