Automation, robotics, brains, and a new theory of Physics

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In 1985, Douglas Hofstadter wrote: “The major question of Artificial intelligence is this: What in the world is going on to enable you to convert 100,000,000 retinal dots into one single word `mother' in one tenth of a second?” Half of the answer to this question has been in Physics for a century. It is the ***principle of symmetry***: a physical system that has a symmetry also has a conservation law. “Mother'” is an invariant representation or ***cognit*** in our mind. The conservation law says that “mother'” is invariant under transformations such as her displacement, rotation, or conditions of light. We recognize her because we ***associate*** the word “mother” with something that does not change.

The other half of the question, is how to find the object that is conserved, “mother” in this case, by ***using a machine!*** This Workshop is about Automation and Robotics. A task is not automated until humans are out of the loop. So our goal is to build a machine that can find “mother” from signals coming from a camera.

The answer to the second half of the question, is not in today's state-of-the-art Physics. It requires a whole new theory of Physics. Causality -- our world is causal, at least outside of the black holes -- is the principle that effects follow their causes. Causal sets are used to formalize causality. But causal sets ***always*** have a symmetry! Hence, they always have a corresponding conserved quantity. Which, in the new theory, is found by the minimization of a recently discovered ***action functional***. The resulting conserved quantities are networks of hierarchical structures made of elements of knowledge, or ***cognits***. Each hierarchy is a distributed network of cognits, and each cognit is in turn a network of smaller cognits, with the lower bound determined by the ***granularity*** of the existing knowledge. All calculations can be carried out on a computer, and it is now possible to build a machine that answers Hofstadter's question.

These networks are mathematical and have rigorous mathematical properties. ***Predictions*** can be made from the theory, and compared with observational evidence from other disciplines, such as Neuroscience. In fact, the mathematical networks are very similar to those observed in cognition. Fuster (2005) (references are in www.SciControls.com), describes the brain as a ***distributed network of cognits*** with the properties he specifies in a 7-point list. This list is nearly identical to the mathematical properties of causal networks. The causal theory, which is completely unrelated and independent of the brain, predicts that ***dendritic connections*** in the cortex must have an optimally short total lenght. Cuntz (June 2012) proposed a 2/3 power law, which is optimally short. The law has extensive experimental support, and this finding is overwhelming proof of the theory. Lerner (August 2012) has studied the dynamics of evolution, and proposes an ***entropy functional*** to explain it. Recent advances in DNA science (September 2012) describe ***DNA*** as a collection of “extraordinarily complex networks that tell our genes what to do and when, with millions of on-off switches,” suggest that DNA itself is a self-organized structure and that mathematical models of DNA based on the new theory will soon be needed. The ***GUAPs***, adaptive tasks easy for humans but difficult for computers to perform, can now be solved. They include robotics, the recognition of image and voice, the semantic web, natural language, associative memories, and others. They all have exact mathematical solutions that can be implemented on a computer. Large scale applications to machines with GUAP capabilities can be anticipated. Why couldn't other researchers connect the dots? Because they didn't have the action functional and had no reason for concern about the role of causality. But now, I have published, and they will connect the dots, very soon. What are we waiting for?

Sergio Pissanetzky was educated at the renowned Balseiro Institute of Physics, on the shores of a remote glacier lake SW of Argentina. He worked as a researcher and professor of Physics at the Universities of Buenos Aires and Córdoba, and Chairman of the Computer Center, Atomic Energy Commission of Argentina. He joined Texas A&M and the Supercollider project in Texas in 1984. He served as an editor for the Int. J. for Computation in Electrical and Electronic Engng., an advisor for the Int. J. Métodos Numéricos para Cálculo y Diseño en Ingeniería, and a member of the Int. Comm. for Nuclear Spectroscopy. Currently retired, he does what he loves best: research in Physics and Artificial Intelligence.