Collective Mind Approach to Active State Model.

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The Active State Model (ASM) is defined as an autonomous object (aircraft, spacecraft, robot, intelligent agent) that can evaluate its state or a sequence of states, compare them to the nominal ones, analyze the difference, detect possible abnormalities, and remove them. ASM may also include the ability to forecast future states and make decision about optimal behavior with a certain degree of independence from environment. Adopting concepts from psychology, AMS can be characterized by self-image (an ability to determine nominal values of the sensor data using its own mathematical model), the self-awareness (the ability to process the current sensor data and compare them with the nominal values) and the image of the "world" that includes the objects interacting with the ASM. The last concept implies that different ASM may shear a similar vision of the world, and that help them interact more efficiently; this property leads to the concept of collective mind. This concept has appeared recently as a subject of intensive scientific discussions from economical, social, ecological and computational viewpoints. It can be introduced as a set of units of intelligence (say, neurons, or interacting agents) that can communicate by exchange of information without an explicit global control. The objectives of the agents may be only partly compatible and partly conflicting i.e., they can cooperate or compete. The exchanging information may be at times inconsistent, often imperfect, non-deterministic or delayed. Nevertheless, observations of working insect colonies, social systems, and scientific communities suggest that such collectives of agents appear to be very successful in achieving global objectives, as well as in learning, memorizing, generalizing and predicting, due to their flexibility, adaptability to environmental changes, and creativity. But the main "secret" of their success is the ability to shear the global knowledge about the world; that creates a context for their communications, and makes all the interactions more efficient. In a more sophisticated collectives, the self-image, and self- awareness, are complemented by the chain of reflective images "what do you think I think you think..." and that introduces additional dimensions of complexity in collective behavior of the agents.

All the previous attempts to develop models for so called active systems have been based upon principles of Newtonian and statistical mechanics. These models appear to be so general that they predict not only physical, but also some biological, economical, as well as social patterns of behavior exploiting such fundamental properties of nonlinear mechanics as attractors. Not withstanding indisputable successes of that approach, (neural networks, distributed active systems), there is still a fundamental limitation that characterizes these models: on a dynamical level of description, they propose no difference between a solar

system, a swarm of insects, and a stock market. Such a phenomenological reductionism is incompatible with the first principle of progressive biological evolution. According to this principle, the evolution of living systems is directed toward the highest levels of complexity if the complexity is measured by an irreducible number of different parts that interact in a well-regulated fashion. At the same time, the solutions to the models based upon dissipative Newtonian dynamics eventually approach attractors where the evolution stops (until a "master" reprograms the model). Therefore, such models fail to provide an autonomous progressive evolution of living systems. Turning to stochastic extension of Newtonian models, it should be noticed that according to the second law of thermodynamics, their evolution will be regressive, i.e., their complexity will eventually decrease.

The objective of this work is to develop a new mathematical formalism within the framework of classical dynamics that would allow one to capture the specific properties of natural or artificial living systems such as formation of the collective mind based upon abstract images of the selves and non-selves, exploitation of this collective mind for communications and predictions of future expected characteristics of evolution, as well as for making decisions and implementing the corresponding corrections if the expected scenario is different from the originally planned one. The approach is based upon our previous publications [1-3], that postulate that even a primitive living species possesses additional non-Newtonian properties that are not included in the laws of Newtonian or statistical mechanics. These properties follow from a privileged ability of living systems to possess the self-image and to interact with it. The mathematical formalism is based upon coupling the classical dynamical systems (with random components describing uncertainties in initial conditions as well as by Langevin forces) representing the motor dynamics, with the corresponding Fokker-Planck equation describing the evolution of these uncertainties in terms of the probability density and representing the mental dynamics. The coupling is implemented by the information-based supervising forces representing the self-awareness. These forces fundamentally change the pattern of the probability evolution leading to a major departure of the behavior of living systems from the patterns of both Newtonian and statistical mechanics. Further extension, analysis, interpretation and application of this approach to the collective-mind-based communicating agents is addressed in this work. The approach is illustrated by the dynamics of a dialog between two agents having an incomplete information about each other and complementing the lack of information with the collective mind.

References.

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