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An Approach for Autonomy: A Collaborative Communication Framework for Multi-Agent Systems

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Abstract

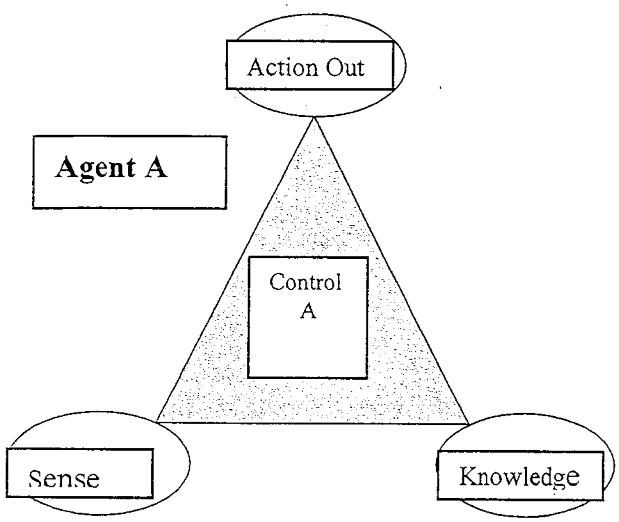
Research done during the last three years has studied the emersion properties of Complex Adaptive Systems (CAS). The deployment of Artificial Intelligence (AI) techniques applied to remote Unmanned Aerial Vehicles has led the author to investigate applications of CAS within the field of Autonomous Multi-Agent Systems. The core objective of current research efforts is focused on the simplicity of Intelligent Agents (IA) and the modeling of these agents within complex systems. This research effort looks at the communication, interaction, and adaptability of multi-agents as applied to complex systems control. The embodiment concept applied to robotics has application possibilities within multi-agent frameworks. A new framework for agent awareness within a virtual 3D world concept is possible where the vehicle is composed of collaborative agents. This approach has many possibilities for applications to complex systems.

This paper describes the development of an approach to apply this virtual framework to the NASA Goddard Space Flight Center (GSFC) tetrahedron structure developed under the Autonomous Nano Technology Swarm (ANTS) program and the Super Miniaturized Addressable Reconfigurable Technology (SMART) architecture program. These projects represent an innovative set of novel concepts deploying adaptable, self-organizing structures composed of many tetrahedrons. This technology is pushing current applied Agents Concepts to new levels of requirements and adaptability.

Standard applications of agent technology involve agents that must be adaptable, intelligent, and interactive with the environment where the agent software is applied. This level of growth in agent capabilities has often evolved to requirements of a complex system within itself. The agents must possess more advanced sensory inputs to meet the requirements of dynamic environments and the agents must also possess an increased

computational intelligence capability not easily achieved given the current state of microprocessor horsepower.

The proposed research will address the issues of complex systems from the perspective of CAS. This perspective looks at the entire world of the multi-agent's interaction. This includes the multi-agent body (robot, TETwalker, vehicle, etc.), the dynamic physical world the agent body must operate in, and the interrelation between the agents and that environment. Drawing from previous work on the obtainment of knowledge (Figure 1) the agent will hold a degree of relationship with itself, other agents, and eventually overall behaviors and goals.



The relationship held plays an important role in the communication architecture that will be developed in the proposed framework. To emulate the basic structures discussed in current CAS research the agents must be built with as little intelligence as possible. Information shared with higher order agents must incorporate the communication channels to allow the passing of data to the agents that would react to the information and thus cause the action required or desired. If done successfully the framework would include a relationship between the lower agents and the 3D virtual world that could allow the vehicle to converge on an imaginary spot in the virtual world much like Particle Swarm Optimization (PSO) conversion, Cellular Automata (CA), or fractal conversion. The benefit of such a framework would allow the virtual spot to also exist within the vehicle itself or represent an agent node.

The CAS techniques studied have presented a common core element that involves the emersion of CAS properties. That element is the inclusion of randomness and the degree of randomness. This research will investigate the effects of randomness as part of the equation of CAS properties. As in nature and biological colonies, the random interactions that take place in CAS play an important role in evolving properties that contain higher degrees of capabilities than the initial components of the system.

The benefit of applying CAS techniques is the emersion of a higher order of capability, adaptation, self-organization, self-configuring possibilities, and an evolution of control through the use of simple agents. This process exists in nature and biological processes. The struggle is predicting the emerged property or even the property desired. It is suggested that the development of this framework can provide a novel control strategy that can be applied to the GSFC TETwalker that allows the growth and adaptation to multi-tetrahedrons through relationships with each agent and the virtual dynamic world built for simulation. These agents would require a simpler intelligence and therefore provide a more obtainable application timeframe for the control of the tetrahedron structures.