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Empirical versus Formal Approaches to Agent-Based Systems

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Synergies exist between empirical and formal approaches to agent-based systems. We discuss these approaches and posit that whether to follow an empirical or formal approach depends on the domain of interest and the properties of the results we seek.

The focus in the empirical approach to agent-based systems is system-centric. In the empirical approach we remain grounded in objects and events of the real world. Uncertainties and other realities in the world that are difficult to formalize are best captured by empirical approaches. In domains in which observational data is available, such as biological systems, empirical approximations of real phenomena are useful. Systems of mobile robots as agents are all empirical systems and by observation we extrapolate principles, methodologies, and architectures. With the empirical approach we seek to measure, experiment, and gain access to metrics and benchmarks.

The focus in the formal approach to agent-based systems is model-centric. Cognitive ingredients of complex mental states as well as precise models and requirements of critical systems are best captured by formal approaches. Models are often designed for abstract ways of thinking about empirical objects and events. In such abstract thinking that simplifies the real world, theories are possible. Theories in turn may offer useful theorems. In environments that must provide guarantees of success, the best method is to develop formal methods that lead to theories. In such a method an inference system might be needed that is sound, complete, or rational. Using a logical formalism is a formal approach that provides properties that offer concise and expressive languages and representations.

It is conceivable that in a given problem, both approaches are useful and there is useful synergy. Let's consider an example that is guided by a formal system. Cohen and Levesque's Joint Intentions Theory [1] offers the concepts and conditions needed to form a team that works on a common goal. Following the concepts and conditions of joint intentions theory, a system can be implemented that enables team work. For example, Milind Tambe's STEAM obeys the Joint Intentions Theory and models interactions in domains like the game of soccer [2].

References

[1] Cohen, P. R., and Levesque, H. J. 1990. Persistence, intention, and commitment, Cambridge, MA: MIT Press, Cambridge, MA.

[2] Tambe, M. 1997 Towards Flexible Teamwork Journal of Artificial Intelligence Research, Volume 7, Pages 83-124.