Three Challenges for Formal Methods and Models

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"Prediction is difficult especially about the future" Niels Bohr

1. Introduction

As part of the Panel Discussion on Future Directions I would like to identify a question for each of three areas of work that I feel will be important for the future of formal methods. These areas are:

- Adaptability
- Granularity
- System scoping

I will briefly discuss each in more detail.

2. Adaptability

Some systems can vary over time. This is especially true for agent-based autonomous systems. Intelligent agents evolve over time based on many factors including being embedded in a changing environment and having to adjust to it, and having the capability to learn based on self assessment against performance criteria established for the agent. Formally stated:

Question 1. Given that $M(S_t) = T$ (i.e., the model of system S at time t is a correct model) what can formal modeling do to allow one to evolve the M to ensure that $M(S_{t+1}) = T$ where S has changed over time because of system environmental changes or "learning"?

Is there a tried and true way to evolve the model M to reflect the changes the system S has undergone because of adaptation to environmental changes or the system's learning process?

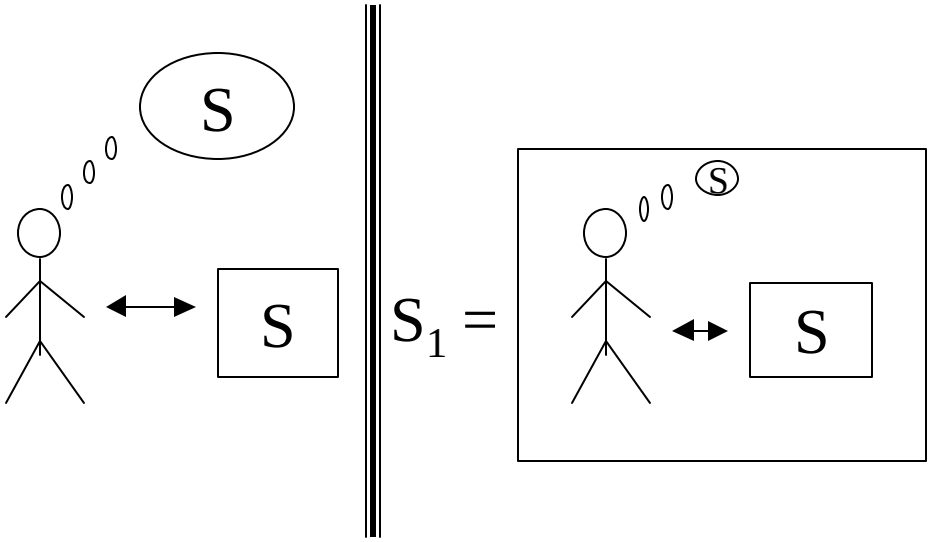
3. Granularity

The next question is related to what I call granularity. As systems get "more complicated" a single formal method or model may be inappropriate or not feasible for the system as a whole. System decomposition into components and the individual modeling of each component by an appropriate formal technique tailored to that component may be required. Multiple differing formal and /or heuristic models may be required to address the various nuances of the system's components. The question is: will an algebra of models be available to allow composition of the individual component models into a model of the entire system, i.e., will we have

$M(S) = M_1(S_1) + M_2(S_2) + \ldots + M_n(S_n)$?

4. System scoping

In classical cybernetic theories, a system has to have a definite boundary that delimits it from its environment. The question, which I raise regarding system scoping, has to do with what is included within the boundary. The following two-sided figure illustrates one instance of the question regarding scope.



The left hand side illustrates a person interacting with a system S according to his mental model of S. The right hand shows the user and his mental model as being an integral part of a larger system S_1. Formal methods today address the modeling of system S. Will formal methods be able to address the modeling of system S_1, i.e., systems in which the human is an integral component?

5. Conclusions

This brief panel presentation has addressed three question which I feel will need to be addressed if formal modeling techniques are to make an impact on future complex systems modeling.