Encoding and Using Knowledge on Population Dynamics Processes for Equation Discovery

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The typical approach to modelling population dynamics is that an expert writes down a set of differential equations that capture the most important relationships in the domain. The equations are based on his knowledge: the expert has to have both modeling knowledge and knowledge of the domain he models. While the structure of the equations is determined by the expert, the coefficients in the equations might be calibrated later on using measured data.
Automated modeling approaches, such as equation discovery, typically use measured data only to find both the structure and the coefficients of the differential equations. Typically, no modeling knowledge or knowledge about the domain is explicitly used. In cases where such domain is used, it has to be represented in formalisms unfamiliar to ecologists or mathematical modeling experts, such as the formalism of context-free grammars.
In this paper, we present a representation for general modeling knowledge, as well as domain specific knowledge, for the area of population dynamics. This formalism is centered on population dynamics processes, such as growth and decay, predation, symbiosis, parasitism and competitive exclusion. The general modeling knowledge can be easily formulated by mathematical modeling experts and can be re-used across different domains. The domain specific knowledge can be easily formulated by ecologists for each domain (ecosystem modeled) separately. We also present an equation discovery system that can make use of knowledge represented in the proposed formalism by transforming it to context-dependent grammars.