The Use of Typed Lambda Calculus for
Comprehension and Construction of
Simulation Models in the Domain of Ecology

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1990

Abstract

We are concerned with two important issues in simulation modelling: *model comprehension* and *model construction.* Model comprehension is limited because many important choices taken during the modelling process are not documented. This makes it difficult for models to be modified or used by others. A key factor hindering model construction is the vast modelling search space which must be navigated. This is exacerbated by the fact that many modellers are unfamiliar with the terms and concepts catered for by current tools.

The root of both problems is the lack of facilities for representing or reasoning about domain concepts in current simulation technology. The basis for our achievements in both of these areas is the development of a language with two distinct levels; one for representing domain information, and the other for representing the simulation model. Equally importantly, we make formal connections between these two levels. The domain we are concerned with is ecological modelling.

This language, called *Elklogic,* is based on the typed lambda calculus. Important features include a rich type structure, the use of various higher order functions, and semantics. This enables complex expressions to be constructed from relatively few primitives. The meaning of each expression can be determined in terms of the domain, the simulation model, or the relationship between the two. We describe a novel representation for sets and substructure, and a variety of other general concepts that are especially useful in the ecological domain. We use the type structure in a novel way: for controlling the modelling search space, rather than a proof search space.

We facilitate model comprehension by representing modelling decisions that are embodied in the simulation model. We represent the simulation model separately from, but in terms of a domain model. The explicit links between the two models constitute the modelling decisions. The semantics of Elklogic enables English text to be generated to explain the simulation model in domain terms.

Inherent in this is a new approach to model construction which we have implemented in a computer program called ELK. Users build up a sequence of models, each being used to identify and constrain the important modelling decisions for the next one. The first model consists of general domain information (*e.g.* forestry). The second is a description of the particular situation of interest (*e.g.* some forest). Finally a simulation model of that situation is constructed. This approach enables users to communicate in familiar terms as well as significantly reducing the number of decisions that have to be made at any point. Constructing simulation models this way enables them to be self-documenting; this facilitates model comprehension.