Developing Smart Spatial Systems Using CommonKADS

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Visual geographic knowledge which can be extracted from satellite remote sensing images has characteristics which are not commonly found in non-visual domains. Traditionally geographic expert systems have worked either at the pixel level of raster images or the object level of vector images. This has shortfalls when knowledge acquired from a human image interpreter has to be incorporated into an expert system to aid interpretation.

The aim of this paper is to show how spatial reasoning systems in a geographic context can be developed using CommonKADS. Figure 1 gives an overview of the interconnecting CommonKADS models. In this paper only the organizational, task, agent and knowledge model will be discussed in detail.

KADS was initiated as a "Structured methodology for the development of knowledge based systems" (Motta. 1997). The limitations of production rules, combined with their inherent non-reusability contributed significantly to the impetus to develop methodologies like KADS. The two central principles that underlie the KADS approach are the introduction of multiple models as a means of coping with the complexity of the knowledge engineering process, and the use of knowledge-level descriptions as an intermediate model between expertise data and system design.

Motta (1997) coins the term “knowledge modeling revolution”, which refers to the paradigm switch from symbol level (rule based) approaches to knowledge level task centred analysis. This heralded the necessary decoupling of the task specification and the problem solving method.

The CommonKADS methodology has been used extensively in a wide range of domains, but not that of spatial reasoning. The advantage of CommonKADS is that it provides a full model of an application, not just a model of the knowledgebase (Schriber et al 2000) .

In developing any knowledge based system, including spatial system, the first step is to develop the organisational, agent, communication and task models. The *Organisational Model* is a model which documents the objectives of the system and identifies opportunities of value to the organisation. One of the advantages of CommonKADS is that the organizational model provides an analysis of the socio-organizational

environment that the KBS will have to function in. This includes descriptions of functions within the organization (Wielinga and Schreiber, 1993). The organisation model is also used to identify risks of fielding a KBS. particularly now KBS are more widely used and there is less risk of KBS failure through technical issues (De Hoog, 1993).

The *Agent Model* provides an understanding of the systems users and identifies how these users or agents will perform their tasks (Gustafsson 1994). An agent in this context is a person, hardware or software which interfaces with the KBS. In a spatial system this could be a GIS.

The *Communication Model* models the interaction of the system with the user, other and other system components. It models how software and users of the system work together and specifies the environment in which KBS must work.

The CommonKADS *Task Model* specifies how the functionality of the system is achieved (Gustafsson 1994). The design of the task model The task model links to the agent model to identify the people, hardware or systems that perform the task, and will use information specified in the communication model, to operate in the domain defined in the organizational model.

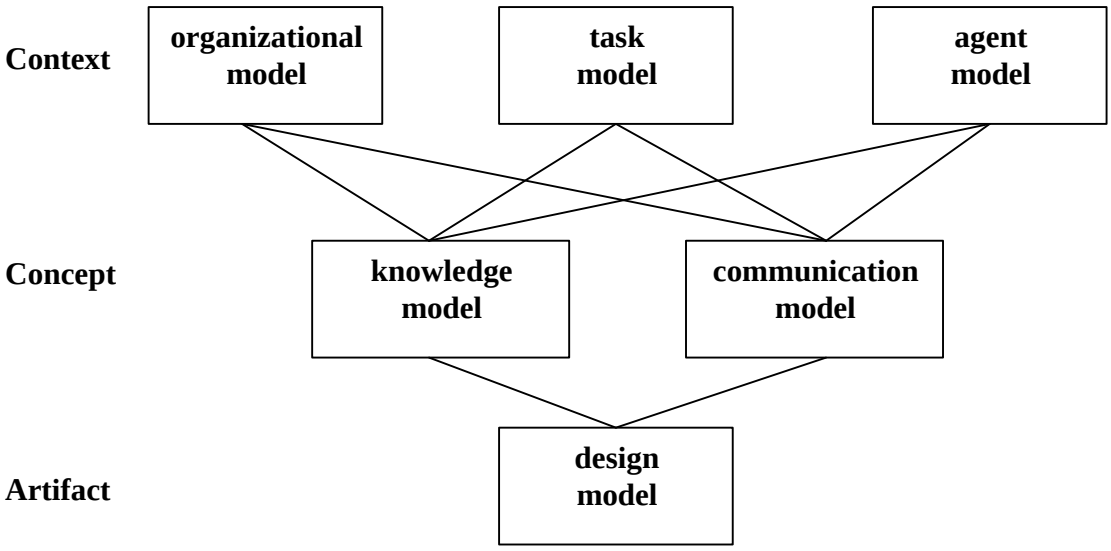

Figure 1 The CommonKADS knowledge classification scheme (Schreiber et al, 2000, p18)

The Knowledge Model defines the knowledge necessary to meet the objectives specified in the Organisational model and the tasks in the task model. It is split into three layers.

The CommonKADS *Domain* Layer is knowledge describing a declarative theory of the domain. Knowledge at this level should be represented in a way that is independent of the way in which it is to be used. It defines the conceptualisation and declarative theory of

the problem domain and provides the knowledge to carry out given tasks. In other words it contains facts, rules and domain types. The other layers contain knowledge to control the use of knowledge from the domain layer (Fensel and Van Harmelen, 1994).

The *Inference Layer* specifies how to use the knowledge from the domain layer. It restricts the use of the domain layer and abstracts from it. A formal specification language has been developed to record knowledge in each of the layers (Schreiber et al 1994).

In the geographical knowledge classification scheme, knowledge about specific image primitives, like an instance of the crop class 'potato', would be held at the domain level. At the task level there would be an inference mechanism which would identify all potato crops and which could be reused to identify all other crops.

The *Task Layer* represents a fixed strategy for achieving problem solving goals. It includes a specification of the goals related to a specific task (which is documented in the *Task Model* shown in Figure 1) and indicates how these goals can be decomposed into subgoals.

The advantage of using a series of integrated models to develop knowledge based geographic systems is that not only is knowledge modelled, but also the system requirements and the environment it will operate in. This is an aspect that appears to have been lacking in the development process of most spatial knowledge based systems. By using this type of modelling, an information system that meets a specific users needs can be developed in a form that encourages structure and reuse of components, be they knowledge components or interface components.

CommonKADS has been used in a wide variety of domains, but, apparently not in the spatial domain. Given that CommonKADS is designed to exploit ontologies in the form of the CommonKADS Library (Valente et al, 1998), collaborative systems could be built reusing knowledge from the domain layer and inference layer of the knowledge model. In other words there is no need to build specific spatial extensions to CommonKADS, rather a library of model components of a spatial nature could be developed.

This paper will present an example based on the interpretation of satellite imagery in an agricultural domain where expert knowledge is captured and applied. A set of CommonKADS models will be presented and evaluated

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