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Relational Database Management System as an Expert System Building Tool in Geographic Information Systems

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Abstract

After the introduction of the topologically structured geographic information system(GIS) with relational DBMS, the attribute data can be handled without considering locational data. By utilizing of the characteristic of the relational DBMS, it can be used as an expert system building tool in GIS.

The relational DBMS of the GIS furnishes the data needed to perform deductive functions of the expert system, and the rule based approach provides the decision rules. Therefore, rule based approach with the expert judgement can be easily combined with relational DBMS.

Relational Data Base GIS

Geographic Information System(GIS) is the information system which the land data are to be encoded, stored, retrieved, and analyzed according to the user-defined specifications. It consists of two sets of data: locational and thematic data. New systems include a trade-off between raster based and vector based GIS. The former is better in handling thematic data because of its simple data structure, and the latter is better in handling spatial data because of its topological data model. In order to manipulate both data well, a hybrid data model in GIS has emerged, the topologically structured GIS with relational DBMS. For thematic data processing and tabular data structures and algorithms, relational data models have advantages because of their adaptive and simple characteristics.

Before relational data base GIS' were developed, attribute handling was difficult in a vector based GIS. The technique used in the relational database GIS is to perform overlays on data sets containing no direct thematic data, but simply pointers to other tables containing it. The data sets resulting from this operation act as indices to allow relations between separate data sets.

Expert Systems

The expert system is a major branch of artificial intelligence. An expert system consists of a body of knowledge pertaining to a specific domain and the mechanisms to process the knowledge in order to find solutions to complex problems(Missikof and Wiederhold, 1985). The purpose of expert systems is to make it possible for non-experts to make use of an expert's knowledge by incorporating it in a computer system. Given a problem, an expert system is capable of using its expertise to search out and derive possible solutions, based on its stored knowledge.

Expert Systems in Relational Database GIS

Recently, expert systems have been applied in the GIS field including land evaluation (Burrough, 1986). Robinson and Frank(1987) identified four major problem domains of GIS where expert system technology has been developing: map design, terrain/feature extraction, geographic DBMS, and geographic decision support systems. Of these four domains, relational DBMS can be used as an expert system building tool in GIS. According to Missik of and Wiederhold(1985), expert systems and DBMS can be used together; the expert systems performing deductive functions, while the DBMS manages the database. The relational DBMS acts as a server to the expert system, supplying on demand the data that the latter requires. This is the approach suggested in Japanese fifth generation documents(Oshuga, 1982).

The following describes the logic of relational DBMS as an expert system building tool in GIS.

Figure 1 shows the concept of the use of relational DBMS as an expert system building tool in GIS.

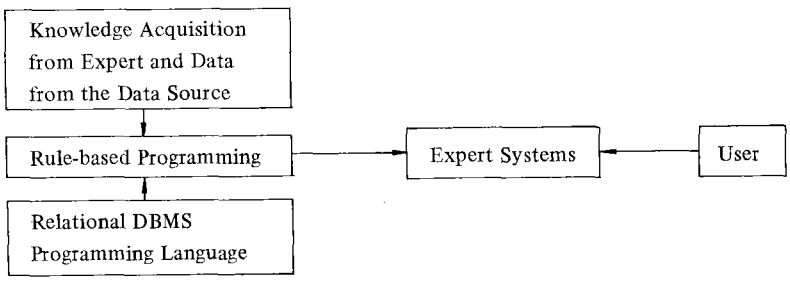

Figure 1. Concept of the relational DBMS use in expert systems application in GIS

Knowledge Acquisition

The knowledge in expert systems should be acquired from experts in a specific domain. This collection of domain knowledge is called the knowledge base which contains facts and rules that use those facts as the basis for decision making. The knowledge base – facts and rules – are applied and processed by inference engine which controls the reasoning of the expert system. Because of the separation of the knowledge and procedures of applying the knowledge, it is easier for the knowledge engineer to design procedures for manipulating this knowledge. It is one of the main characteristics of expert systems(Duda and Gasching, 1981).

Knowledge Organization

In terms of organizing knowledge provided by the expert, heuristic searches can be used – simplications that effectively limit search for solutions, which is organized with most limiting conditions, then searching the candidate attribute data, not whole map units. While an algorithmic method guarantees to produce the correct or optimal solution to a problem, a heuristic method produces an acceptable solution most of the time. For example, in finding soil map units suitable for certain soil absorption field type, the model deletes the soil map units containing limiting attributes first, then searching and comparing the remaining map units based on other attributes(Lee, 1987).

Knowledge Representation

In terms of structuring knowledge in the program knowledge representation, three ways can be considered. They are frame-based, semantic nets, and rule-based approaches. Of these three approaches, rule-based approach can be used in the expert system where the domain knowledge is represented as sets of rules that are checked against a collection of facts or knowledge about the current situation. Advantages of this rule-based approach are in the explicity of rules, and the possibility of review. As a result this approach can be easily applied in the rule-based programming. Rule-based knowledge representation focuses on the use of IF – THEN action. When the IF portions of a rule is satisfied by the facts, the action specified by the THEN portion is performed. This sequential matching of rule IF portions to the facts forms the inference chain, which indicates how the system uses the rules to infer the necessary information.

Constructing Expert Systems Using Relational DBMS

After the acquisition of knowledge from the expert, relational DBMS is used in building the inference engine as an expert system building tool. At this time, rule-based approach is used as an knowledge representation tool and heuristic search is used as an knowledge organization tool.

Conclusions

Several spatial data models can be considered in linking GIS and expert systems. Of several data models, a hybrid data model containing topology of vector data structure and tabular format of attribute data can be used as an efficient geographic data search method. By utilizing the characteristic of relational DBMS, the application in expert systems of GIS has been discussed.

The major advantage of the relational DBMS is to allow different kinds of data to be searched, combined, and compared, because this just involves adding or removing a record. The relational DBMS of the GIS furnishes the data needed to perform the deductive functions of the expert system. Thus, rule-based approach with the expert judgement can be easily combined with relational DBMS. The rule-based approach provides the decision rules, and the relational DBMS provides the necessary data quickly. It is expected that relational data base GIS will be used more frequently for analytical, or expert systems approach in land evaluation.

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