# Ontological Support for Teaching Strategy in Intelligent Visual Reasoning Tutor

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**Abstract**. IVRT is an ITS for visual reasoning, using the missing view problem. It combines an ITS framework with a solid modeling kernel that supports hint-generating rules using geometric reasoning. We develop an ontology for IVRT's hint generation rules, and a separate ontology for IVRT's teaching strategy. Teaching strategy rules are stored in a custom text format, with compilation to Jess.

The ability to visualize and reason about geometric aspects of 3D objects is critical for success in many disciplines in engineering and architecture. The missing view problem [1], shown in Figure 1, is typically used in visual reasoning instruction. Two consistent, principal orthographic views are given, and the learner must provide the third view corresponding to a valid 3D solid object.

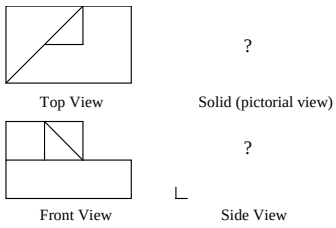


Figure 1. Missing view problem

We have developed an instructional software system called Intelligent Visual Reasoning Tutor (IVRT). IVRT's missing view problem solving module [2][3] implements a solid modeling kernel that can represent and display a partially-constructed 3D solid. It provides interactive sweeping operations [4] to incrementally construct faces of a solution solid.

The missing view module's hint generation knowledge is implemented as a set of rules in CLIPS [5], shown in Table 1. We develop an ontology to represent the knowledge behind these rules, shown in Figure 2, and instantiate a model of these rules, shown in Figure 3. This model explicitly represents the kinds of knowledge used by each rule, and identifies the major programming patterns involved in their implementation.

| |
|---|
| 1. Create visible faces first (top and front faces). |
| 2. Create hidden faces next (bottom and back faces). |
| 3. Create faces using *construct* command last (right faces, then left faces). |
| 4. Prefer the face that is adjacent to the most correct faces. |
| 5. Prefer the face with the most incident edges. |
| 6. Prefer the face whose normal vector contains the most zero components. |

Table 1. Hint-generating rules

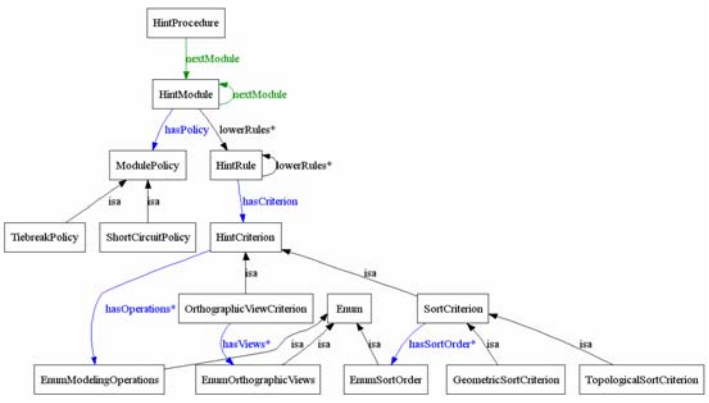


Figure 2. Ontology classes for hint-generating rules

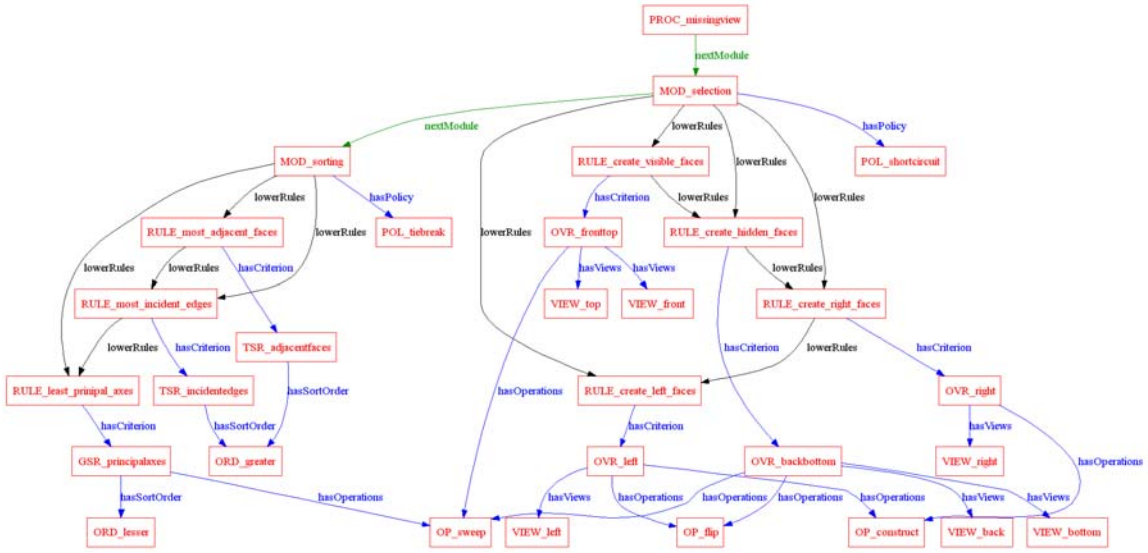


Figure 3. Ontology modeling for hint-generating rules

IVRT's ITS framework uses an ontology of learning contents and learner's status, shown in Figure 4. IVRT's teaching strategy is then represented as rules, which are stored in a custom text format based on the grammar shown in Table 2. This format is a syntactically simplified version of Jess, with quantifiers and implicit variables. Rules are compiled to Jess for execution, using a recursive-descent parsing approach implemented in Jess.

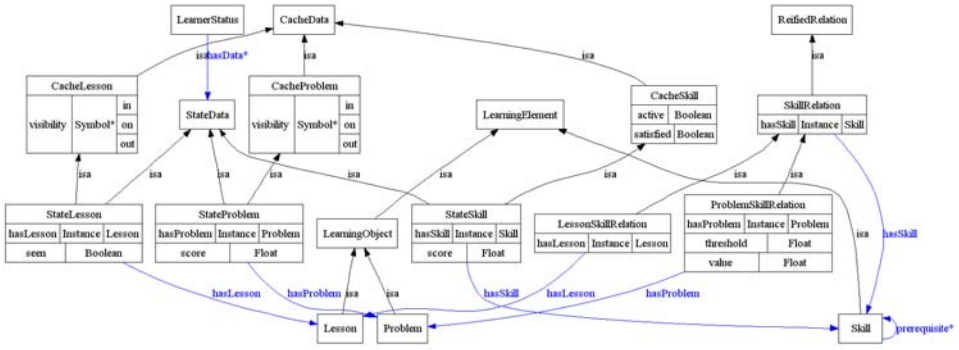


Figure 4. Ontology modeling of IVRT's learning contents and learner status

| |
|---|
| **Rule** = RULE $name<br>FOREACH %main-class **HasExpr***<br>[THRU %prop]<br>[IF **Antecedent**] THEN **Consequent** |
| **HasExpr** = HAS %prop = %value |
| **Antecedent** = **Quantifier** %reified-rel **HasExpr*** |
| **Quantifier** = ANY \| ALL |
| **Consequent** = [IN %modified-class] SET %prop %value |

Table 2. Rule grammar for simplified rule format

| |
|---|
| Rule-3a. For each lesson that uses the conservative approach: if all associated skills are active, show this lesson. |
| RULE lesson-3a<br>FOREACH Lesson HAS approach = conservative<br>IF ALL LessonSkillRelation HAS active = TRUE<br>THEN IN StateLesson SET visibility on |

Table 3. Example of teaching strategy rule

## References


[1] Wilde, D. J., "The geometry of spatial visualization: two problems", *8th IFTOM World Congress*, Prague, Aug. 1991.

[2] Kim. Y. S., Moon, C., Chauhan, S., Hubbard, C., Mengshoel, O., and Zhao, H., "Visual Reasoning Tutor (VRT): Instructional Software System for Missing View Problem", *Proc. ASEE Engineering Design Graphics Division Conf.*, Ames, IA, Nov. 1995.

[3] Hubbard, C., Mengshoel, O., Moon, C., and Kim, Y. S., "Visual reasoning instructional software system", *Computers and Education*, Vol. 28, No. 4, pp. 237–250, 1997.

[4] Zhao, H., and Kim, Y. S., "Geometric Operations for Visual Reasoning of a Solid from Orthographic Projections", *Advances in Engineering Software*, Vol.30, No.7, 1999.

[5] Mengshoel, O. J., Chauhan, S., and Kim, Y. S., "Intelligent Critiquing and Tutoring of Spatial Reasoning Skills", *AI in Engineering Design, Analysis, Manufacturing*, Vol.10, 1996.