Ontology-based Learning Resource Dynamic Generation with Learning Goal

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Abstract—In this paper, based on ontology, a kind of system architecture is proposed to generate learning resource dynamically with learning goal, which is called LRDG. At the meantime, a semantic model and related processing methods are designed. The semantic model consists of knowledge object ontology, learning material ontology, learning action ontology and instructional strategy rule format. Processing methods include knowledge object decomposition, knowledge object selection, rule reasoning engine, and learning resource generation. With LRDG, the learning resource can be generated at learning time according to learner’s present knowledge state. Also, a system is implemented with J2EE platform and Drool rule engine, and a prototype course is developed. At last, the author gives experiment result and draws conclusion.

Keywords— Ontology; Semantic Model; Instructional Design; Learning Goal; Learning Resource Dynamic Generation

I. INTRODUCTION

Learning resource dynamic generation (LRDG) means generating learning resource at learning time, which is a key technology in many applications of e-learning, such as ITS, adaptive learning, personalized learning, ubiquitous learning, and etc. There are two critical issues in LRDG: rapidness and effectiveness. The rapidness means generating resource rapidly in an acceptable delay at learning time dynamically. The effectiveness means, learning with the resource, learner can get the learning goal. Many projects have been dedicated to this research area:

Mizoguchi Lab [1]: focus on Pedagogical model, especially in instructional strategy representation with and-or tree, which can be understood by tools;

Active-Math [2]: focus on represent instructional strategy with a consequence of action, based on OMDoc base, it can generate learning course in terms of the competence of learner, but can not generate resource at runtime; TANGRAM[3]: mainly works on content semantic model, generate comment automatically;

Puzzle [4] aims to create learning objects that are adaptable, shareable, pedagogically explicit, dynamically generated and able to fulfill a specific competence need, but it is only on its starting point.

Based on above achievements and ontology technology, this paper will propose a semantic model and system architecture according to the present knowledge of the learner, and transform the learning goal into learning action sequence and then, generate learning resource for the learner. It is called Learning Resource Dynamic Generation (LRDG).

II. A SYSTEM ARCHITECTURE OF LEARNING RESOURCE DYNAMIC GENERATION

Figure 1. System Architecture of LRDG

Information resource is only a media to reach the learning goal of e-learning. The effective way to get learning goal is by
use of instructional design method in which instructional strategy is adopted properly. Figure-1 depicts the system architecture to generate learning resource according to present state of learner’s knowledge at learning time based on learning goal. One feature of LRDG is that it manipulates learning resource based on ontology, which means that computer can understand learning resource and produce effective learning action. Another feature is that the instructional strategy rule is also represented in a semantic format and can be utilized by computer, which means that the instructional design can be done by computer, and further this is the key to insure the effectiveness of the generated learning resource.

The working principle of LRDG is as follows:

Step 1: Choosing a Learning Goal
Output: CP+KO

Step 2: Decomposing KO into SKO
Output: KDG

Step 3: Selecting a KO to learn
Output: KO

Step 4: Getting the Type of the KO
Output: KT

Step 5: Generating Instructional Strategy with CP|KT
Output: Learning action sequence

Step 6: Generating learning resource
Output: [material| operation] sequence

Step 7: Testing
Output: Present Knowledge State of the learner;

Step 8: Goal Check
if meeting the Goal, then goto Step 9;
else goto Step 3

Step 9: End or Select another Learning Goal.

Some symbol abbreviations are interpreted as follows:

CP: stands for Cognitive Performance, which means the effect of learning on cognition.

KO: stands for Knowledge Object, which means the concrete knowledge for learner to learn.

SKO: stands for Simple KO, means a knowledge object which does not depend on any other KOs.

CKO: stands for Composition KO, a knowledge object depends on other KOs.

KDG: stands for knowledge dependent graph whose nodes are depended by root KO.

KT: stands for Knowledge Type, is the set of knowledge classes according to some knowledge classification criterion. As there is not a consistent agreement to the knowledge classification, the classification by Anderson [5] is adopted in this paper.

III. Ontology and Method Design

LRDG includes some ontologies and modules to get a learning goal, which are demonstrated in the following.

A. Ontologies Design

An ontology is a formal representation of a set of concepts within a domain and the relationships between those concepts. It is used to reason about the properties of that domain, and may be used to define the domain. LRDG includes the following ontologies:

Knowledge Object ontology: Knowledge object is the knowledge unit for learners to learn. Knowledge Object Ontology (KOO) is depicted as figure-2.

Learning Material Ontology: Learning material object means the information entity used to learn some KO. So, the learning material object is made for learner to learn the corresponding KO. The learning material ontology is depicted as figure-3.

Learning action is represented as proposition; it includes a predicate and an object of material type which can be used by LRDG module.

Learning goal is a goal which belongs to learning activity, borrowed form philosophy and artificial intelligence, here learning goal is defined as a proposition which consists of Cognitive Performance (CP) and Knowledge Object (KO), expressed as a proposition, CP (KO).
KO is divided into two kinds, simple KO (SKO) and composite KO (CKO). Simple KO (SKO) is a KO relative to a course or discipline which does not depend on any other KOs. Composite KO (CKO): a KO X is a CKO, if X is not a CKO.

Instructional strategy Rule:

```
IF CP (cp) .and. KT (kt)
THEN GENERATE Learning action sequence.
```

CP (cp) has a proposition format, means that the value of cp equals the type of CP. While KT (kt) is also a proposition format, means that the value of kt equals the type of KT.

In this paper, instructional strategy related theory is adopted from Anderson [5] and Gagne [6], its principle is depicted as figure-4.

Some of processing methods are described as follows.

Decomposition of Knowledge Object:

**Inputs:** KO, KO Lib, KO ontology  
**Output:** KDG (KnowledgeDepdenceGraph)

```
KDГ: =null; T:=KO;
Decomposition (T)

IF T is SKO
THEN add T to KDГ; return;
IF T is CKO then S:=DependentSet;
Add S to KDГ;
For all T in S Decomposition(T);
Return.
```

Learning Resource Generation Method:

Means searching material object where its Knowledge Object Name matches the Knowledge Name of KO, and its type matches the material type.

IV. IMPLEMENTATION

A prototype system is implemented with J2EE platform according to the above model and architecture. The system environment is configured as follows. Software environment: Operating System: WinXP, Web Server: Jboss4.2.2, Rule Engine: Drools4.07, Java Tool: JDK1.50, Database: Hibernate3.1, Struts1.2, Development tool: Myeclipse6.0.1.

A rule example in DROOL is depicted as follows:

```
rule "understandconception"
when
gc:IStrategy(category=="fact",action=="3");
then
ArrayList gg=gc.getGs();
ArrayList gg=gc.getGs();
gg.add(new Action("cause","attention"));
gg.add(new Action("tell","goal"));
gg.add(new Action("arouse","preknowledge"));
gg.add(new Action("display", "content"));
gg.add(new Action("give", "example"));
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gg.add(new Action("give", "example"));
```
gg.add(new Action("insurct","learning"));
gg.add(new Action("provide","test"));
System.out.println("it it work");
rule "understandprinceple".

The final system is deployed as figure-5.

The learning interface is demonstrated as figure-7.

B. Conclusion

Based on ontology, this paper proposed a semantic model and system architecture to generate learning resource dynamically at runtime based on learning goal. The system was implemented with J2EE Jboss and Drool tools. The experiment indicates the effectiveness of LRDG. The next work will be refining ontologies of LRDG and doing more experiments.

REFERENCES


