Learner Model in Adaptive Learning System

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Abstract

The adaptive learning system is a hotspot in the field of E-learning and intelligent education researches. Learner model is the key to and core of adaptive learning system. Combined with domestic and international learner model standards of E-learning and characteristics of adaptive learning systems, this paper does research and explore about the determination of personality characteristics, formal description, and mining algorithms of learners to propose a construction method of learner model in adaptive learning system.

Keywords: Adaptive Learning; Learner Model; Personality Characteristic Description; Personality Characteristics Mining Algorithm Style Guide; Examples; Latex Style

1 Introduction

Modern E-Learning generally provides students and teachers a convenient way of teaching without face-to-face at the same time, but also brings some problems, such as Immobilized teaching content and can’t being as the teacher who can give learning strategies according to the students’ learning progress, etc. Adaptive learning system solves the above problems very well, it makes learning simpler, more efficient, more personalized, and can better play the main role of the students. The learner model construction is a basic and core issue of adaptive learning system. This paper will do some research and explore about related issues of it.
2 Learner Model Standards of E-learning

2.1 International Standards of Learner Model

At present, several generic E-learning norms such as the AGR (AICC Guidelines and Recommendations), SCORM (The Sharable Content Object Reference Model) and IMS (Instructional Management Systems) are committed to solve the two major issues of learning resources sharing and interoperability, and have achieve satisfactory results. The international standards of network-based educational technology that are similar to ours include: the research norms of IEEE1482 Learning Technology Committee (LTSC) subordinated to Electrical and Electronic Engineers (IEEE); the Information Management System (IMS) specification made by American international Association of Study.

2.2 CELTS Specification for Learner Model

Having tracked international standards studies and introducing relevant international standards, in accordance with the actual situation of education in China, the Department of Science and Technology in the Ministry of Education organized relevant experts from eight domestic major colleges and universities to develop technical standards for online education, and established the Chinese E-Learning Technology Standardization Committee, referred to as CELTSC. In 2002, the committee launched CELTS (Chinese E-Learning Technology Standards)-the technical standards for online education in China, a total of 27 sub-specification divided into 5 parts and 4 tracking research programs, which is a technology standards system of online educational with Chinese characteristics.

In CELTS, CELTS-11[1] specification is a Specification for learner model: information model. It creates and sets up an individual learner model for learners of any age, background or areas. IEEE1484.2[2] (Standard for Learning Technology Publicated Private Information for Learners) specification divides learner information into 6 major categories, and our learner model has a total of eight major categories with academic information and management information added, each type of learner information with extension. Learner information will be logically divided into personal information, academic information, management information, relationship information, security information, preference information, performance information and portfolio information, also including 69 two sub-elements (See Table 1).

This standard specifies the syntax and semantics (or meaning) of the learner information model, describes the characteristics of learners and their knowledge capacity, involves learning process recording, skills, abilities, learning modes and many other information, and can realize detailed description of the learner from a macro to micro picture. Based on this ontology of the learner information model, we can achieve creating a personal learner information model for a learner.

2.3 Application Analysis of Learner Model

The specification of learner model describes the technical details for each data type, range and others of the learner information. The software developers can increase learner information by
<table>
<thead>
<tr>
<th>Basic elements</th>
<th>Explanation</th>
<th>Sub-elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal information</td>
<td>The learner’s information outside the technology system, not directly related to performance measure.</td>
<td>Label, external label, name, telephone number, e-mail address, mailing address, personal files, and extended metadata</td>
</tr>
<tr>
<td>Academic information</td>
<td>The information that is closely related to learning in the education process with great impact on learning.</td>
<td>Label, external label, university, profession, class, study plans, study completion, and extended metadata.</td>
</tr>
<tr>
<td>Management information</td>
<td>The information related to the learner conducive to learning in the education management system.</td>
<td>Label, external label, expense information, reward and punishment, changes, academic certificates, and extended metadata.</td>
</tr>
<tr>
<td>Relationship information</td>
<td>The information used to describe the relationship between the learner and other different users.</td>
<td>Label, external label, directory entry, relationship, and extended metadata.</td>
</tr>
<tr>
<td>Security information</td>
<td>The information related to the learner’s security credence.</td>
<td>Label, external label, directory entry, security credence, and extended metadata.</td>
</tr>
<tr>
<td>Preference information</td>
<td>The information related to the learner’s learning equipment parameters, learning style, and learning mode.</td>
<td>Label, external label, previous set of preferences, follow-up set of preferences, equipment preferences, interests and extended metadata.</td>
</tr>
<tr>
<td>Performance information</td>
<td>The information of the learner’s learning experiences, learning outcomes, and so on.</td>
<td>Label, external label, owner, date, effective date, expiry date, promulgation, publisher, publishing date, publishing object, learning experience, educational level, size, performance coding schemes, performance measurement, performance value, authentication information, and extended metadata.</td>
</tr>
<tr>
<td>Portfolio information</td>
<td>The learner’s representative works and set of related certificates used to describe and prove the learner’s ability and achievements.</td>
<td>Label, external label, type of media label, media labeling, citation of metadata of the learning object, citation of the performance information, citation of learning, citation of certification, and extended metadata.</td>
</tr>
</tbody>
</table>

Adding them to eight major information categories. As a result of not standardized, all new information belong to the expansion of certain types of information, and they will not be separately identified by other compatible systems. Due to the fact that the deal of a large number of expansion information will lead to lower system efficiency, its amount of expanded information is generally restricted, usually not too much. As for the widely recognized expansion information, they will be added to subsequent specification of new version as standard data items [3].
3 Theoretical Foundation of Adaptive Learning

3.1 The Concept of Adaptive Learning

The various learning styles of human beings can be generally divided into three types: lecture learning, drill learning and adaptive learning. In lecture learning, learners need to remember the knowledge presented in form of oral language, written language, graphics or specific models; the learners acquire mainly the declarative knowledge. In drill learning, learners need to complete specific tasks according to given ways and procedures; they acquire mainly the procedural knowledge. In adaptive learning, learners need to discover new methods and procedures to complete specific tasks, and acquire relevant knowledge in the completion of tasks; they acquire both declarative knowledge and procedural knowledge [4].

Adaptive learning is mainly based on constructivist theory and the theory of cognitive flexibility. The adaptive learning is a way of learning that, in the study of specific examples and the process of solving specific problems, the learners acquire knowledge and skills through positive thinking and operation [5]. Adaptive learning is an active learning. Learners can monitor their own learning process, and choose the most suitable learning content and strategies according to their actual needs.

3.2 The Features of Adaptive Learning System

With the rapid development of Internet and new technologies related, the distance learning system in network environment has greatly advanced. From static pages to interactive pages, the adaptive learning system appears in response to learner personality characteristics. The Columbia University and the University of Net Coach in Great Britain jointly develop an adaptive distance learning system of ELM-ART [6]. ELM-ART is an on-line interactive learning system for LISP courses. It provides adaptive navigation support, curriculum continuity, individual learning outcome diagnosis and support for case-based problem solving.

The Computer College of Carnegie Institute and Psychology Institute of the University of Trier develop an InterBook adaptive learning system [7]. It is an adaptive, interactive, and knowledge-based electronic textbook. In recent years, researchers started to study the adaptive learning systems from a new point of view, including adaptive hypermedia studies in education, such as AHA system [8] and A-Tutor system [9]; the distributed adaptive learning system architecture based on Web Services, such as E-Learning architecture based on Web Services [10] and DS-Tutor system; the learning intelligent space based on web technology of next generation and E-Learning Grid, and so on.

These seven adaptive teaching systems in three recent years have developed from closeness to openness in system and structure studies, from behaviorism towards constructivism in learning theories. The above systems have the following common features:

A personalized learning system with the learner as the main body. According to the learner’s learning needs, learning ability and learning style, the system actively adjusts the learning content, learning style, learning strategy, learning paths and learning support, making the difficulty of learning materials suited to the learner’s level, the presented learning content suited to the learner needs, and the provided guidance suited to the learner’s learning strategies. The whole learning process is learner-centered, personalized to meet the learner’s learning needs,
in which the learner’s dominant position if fully realized.

The self construction of knowledge. Learners actively interact with adaptive learning system, constantly obtain and analyze feedback information, so as to construct their knowledge. By the adaptive learning system recording of the learning process, learners can timely control and adjust their own learning process to achieve optimized learning goals suitable to them.

The adaptive learning system is intelligent. Intelligence is the basic guarantee for the system to realize self-adaptation. It enables the system make comprehensive and scientifically diagnose of the learner’s actual level and psychological conditions, present suited learning content and learning support according to the pre-testing and learning process tracking.

4 Construction of Adaptive Learning System Learner Model

Learner model is the key and core of adaptive learning system. Learner model is the Data Structure which can present cognitive status and study-related non-intelligent factors (like learning preference) of learners. Learner model describes learners’ study situation, personality characteristic and mental status across the board, and reflects the dynamic and static characteristic of learners in the process of study. Its function is to provide the data materials of study status and study-related non-intelligent factors of learners for the adaptive learning system, in order to conduct study ratiocination, judge learners’ study status, estimate learners’ study effects and carry out learning strategy decision-making.

4.1 Proposition of Learning Personality Characteristic Model of Adaptive Learning System

CELTS-11 Learner model regulation is the criterion to notarize distance education, however, as for adaptive learning system, it still lacks descriptions of learners’ personality characteristic. Therefore, we add the information which could represent personality characteristics of learners in Learner model. The models which could form learners’ personality characteristics include following seven aspects: basic information of learners, professional knowledge level and cognition level, study target of learners, current completion status of study target, mature degree of cyberspace learning skills, study style of learners and daily study behavior data.

4.2 Learner Ontology Personality Characteristic Formal Description and Repository

We with the reference of Ling Zeng’s research on learner model [11], basing on deduced learner personality characteristic model, define corresponding formalization description and repository: Definition 1 learner ontology is a nine-element group, OL:=\{Lname, Llevel, Lstatus, Ltarget, Lstyle, Lskill, Llog, RL, AC\}, including:

(1) Seven conception aggregate: Lname, Llevel, Lobject, Laim, Lstyle, Lskill and Llog, and they are learner name aggregate, learner knowledge level and cognitive level, current completion
status of study target name aggregate, study target of learners name aggregate, study style
conception name aggregate, cyberspace study skills mature degree and study behavior log
information aggregate.

(2) One relation aggregate Rc:= \{ hasLevel, hasStatus, hasAim, hasStyle, hasSkill, hasLog \};

(3) One axiom aggregate Ac:= \{ ∈, → \}

According to the analysis results of learner model in adaptive learning system, Lstyle, Lskill,
Ltarget and Llevel respectively defined as followed:

Lstyle:= \{ whole-speech style, whole-presentational style, analysis-speech style, analysis
presentational style, style basing on study process, style basing on study direction, style basing on
educational preference, style basing on cognitive technology development \};

Lskill:= \{ none, seldom, ordinary, proficient, professional \};

Ltarget:= \{ occupation target, academic target \};

Level:= \{ primary, advanced, higher \}.

Any learner at least has one kind of study style, one kind of knowledge level and cognitive
level, a study target and one kind of study behavior log information, and at least one kind of
cyberspace mature degree, one current study completion rate of progress, namely: Cn ∈ Lname →
∃ ≥ 1 Cs ∈ Lstyle \exists ≥ 1 Ca ∈ Ltarget \exists ≥ 1 Cg ∈ Llog \exists Csk ∈ Lskill, \exists Co ∈ Lstatus.

Definition 2 learner repository is a three-element group Kc:= \{ OL, IL, MetaL \}, including:

(1) One learner ontology OL:= \{ Lname, Llevel, Lstatus, Ltarget, Lstyle, Lskill, Llog, RL, AC \}

(2) One learner’s instance aggregate IL;

(3) One learner metadata description MetaL:= \{ identification, goal, qualification, Certification
Licenses, activity, competency, transcript accessibility, interest affiliation, security, relationship \}.

4.3 The Algorithm of Mining the Adaptation to Personality Characteristics in Learner’s Model

There are some typical algorithms on the modern adaptive learning system, such as Liu Jun,
Roach, Zhao Guangshe and so on. Liu’s paper presents that we can analysis the relations be-
tween personality characteristic and learner’s performance by using association regulation. Roach
divide the personality characteristic of learner model into different dimensions, and he proposes
that a data cube-based multidimensional association rules for personality characteristic mining
algorithm–Personal Cube Apriori. Guangshe Zhao joins statistical methods to data mining,
and he proposes that the mining fuzzy association regulation for personality characteristic and
learner’s performance [12]. This paper extends the personality characteristics of learners, and
combined it with time-series data mining of learning logs to obtain the integrated nature of
learners, then comes a reasonable learning strategies. The algorithm as flows:

Clustering Mining of personality characteristics. Acquire and simplify the fundamental
data of personality attribute to reduce learner’s personality attribute dimensions. According
to personality characteristic and the changing characteristics of the learning process, making learner’s personality eigenvector, and clustering data to ground on the distance in the personality eigenvector space. The main data types to investigate: Learners’ basic Information, learner’s knowledge and cognitive levels learner’s study target, current completion status of study target, initial learning styles, learner’s performance log information, etc, to make an attribute matrix.

\[
\begin{bmatrix}
    k_{11}x_{1a} & \cdots & k_{1m}x_{1f} \\
    \vdots & \ddots & \vdots \\
    k_{n1}x_{na} & \cdots & k_{nm}x_{nf}
\end{bmatrix}
\]

There into, \( x_{ij} \) denotes that the number \( j \) object’s number \( i \) property, then multiply one weighting coefficient \( k_{ij} \), showing importance of property.

Through corresponding clustering mining arithmetic, we separate data into different genus and cluster.

Classify learners according to personality cluster results. Through querying personality regulation warehouse and adopting blur regulation form describe relation between personality characteristic and teachers, model-building, self-reflection etc. nine kind of learning strategy, building learners’ adaptive learning strategy. Learners can start a stage of learning according to the learning strategy given by the system.

**Learning diagnosis.** In adaptive learning, learning diagnosis is a very important step, because it is the key basis for adaptive learning system to get general idea of learners’ study capacity and cognitive capacity. Learning diagnosis is that conducting tests to learners with some testing exercises which are proofread by measure theory. And according to learners’ refection we estimate learners’ capability and checking out how proficiently they grasp the domain knowledge. Learning diagnosis is the important foundation for the system to process dynamic organizing with study content. Testing after study, it is mainly a kind of achievement test to learners’ study results, testing if learners reach the due learning target [13]. If it has reached, learners will be suggested to end study or start a new ground study program.

**Analyze the Association Rules of study behavior model and personality characteristic and regulate learning strategies.** In the previous guidance of learning strategies, if learners haven’t reach the due learning target, Log file records substantive information which contains learners’ study preference, communicational situation and study progress, etc, which is the main recourse to gain learners’ dynamic data. Conduct Time-series data mining on these log information could acquire disciplinarian information generated according to time sequence. We could discover relation between usher and subsequence of requesting sequence, in order to discover their study preference and style characteristic etc.

Conducting blur relation analysis on the two vectors gained, acquiring association rules between study behavior model and personality characteristic under certain degree of belief. It mainly includes: combing blur aggregate theory and relation analysis, conducting blur association rules analysis on learner behavior model and personality characteristic, regulation under certain degree of belief. According to the degree of belief of association rules, weighting personality property is adjusted. Adopting association rules above, conduct blur consequence on behavior model to update the personality characteristics of all learners. Arithmetic flowchart is showed as Fig. 1.
5 Conclusions and Future Work

Adaptive learning system is the up-to-date technology of modern distance education, possessing great practical value. Combined with domestic and international learner model standards of E-learning and characteristics of adaptive learning systems, this paper does research and explore about the determination of personality characteristics, formal description, and mining algorithms of learners to propose a construction method of learner model in adaptive learning system. This paper doesn’t specifically analyze the building of learner knowledge model when designing learner model of adaptive learning system. In the future research, we will continue to perfect the system, and conduct acquirement and mining of learners’ personality characteristics in adaptive environment in depth, and research the form of adaptive learning strategy. And further research and study how to build a layered knowledge model based on different subjects to match the learner model.

References


