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Personalized recommendation systems in e-learning

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Abstract

With the expansion of web applications and numerouse developments in communications and knowledge distribution, e-learning – as one of the major applications in this context, has undergone leadning changes and improvements. Nowadays, content development , its shape and format are in less importance of elearning system development issues, but the way of presentation of this content in a manner of personalized and proportional to the learner's learning requirements is one of the most importance problems in e-learning. In the dominant paradigms of education, it is believed that different learners' learning happens through different methods, and every one has his individual information requirements in learning. Considering these differences in the process of learning and training can influence the effectiveness and development of e-learning. Personalized e-learning is a novel approach in e-learning. Applying personalized recommendation techniques in elearning system development can help selection of personalized elearning contents and objects to better meet the requirements of each single learner according to his specific learning needs. In this paper we review rescent advances in personalized elarning content recommendation system development and give suggestions for detectiong learning style of each learner based on the knowledge extraction through the learners' information and introduce an approach to learning style recognistion.

Key words: personalization, e-learning, personalized recommendation systems, modeling, learning style

1 Introduction

Personalized learning presupposes that there exist always qualified teaching ways adaptable to the different ways students achieve their knowledge and skills according to their characteristic, educational background, knowledge, preferences and priorities and can attain the educational goals. Personalization in e-learning includes the way of collecting and filtering the learning and environmental data and information appropriate to the users' preferences and learning requirements, ways of retrieving that information and providing

suitable tools for users access, utilization and benefit from that information in learning. Therefore the first step of personalization is to know the user in a manner that his personal, educational and behavioral information in learning can be recognized by the system, in order to personalize the e-learning content for that user.

Personalization is adaption to a specific user, targeting specific aims arising from his specific aims. Thus the personalization element of e-learning must interact with user and user model (the representation of how the system knows the user), change and adapt some entities in e-learning to discover the best fitting choice for responding to his needs. These changes may be done in different aspects, resulting into a variety of personalization types; the aspects of changing can be mainly divided into three:

1. Personalization of content based on user model
2. Personalization of content form, structure and presentation
3. Total Personalization including both aspects

Based on these aspects the personalization types can be categorized as:

- ***Explicit*** or ***Implicit***: according to user model and based on the defined parameters in user model or without referring to user model and based on just the status and conditions.
- ***Perceivable*** or ***Hidden***: sensible and receivable by user or not.
- ***Predictive*** or ***Deterministic***: done before being used by the user or meanwhile of user interaction.
- ***Controlled*** or ***Uncontrolled***: optional choices available for user to control and customize the material or uncontrollable by user.
- ***Individual*** or ***Stereotyped***: personalized for a specific user or for a format and style of users.

Personalization may be applied in different levels as well (Figure 1). These levels are listed below (ascending). The higher the level of customization goes, the implementation becomes more difficult:

- ***E-Learning Course Catalogue*** - No customization
- ***Customized Learning Environment*** - Based on learner profile
- ***Customized Learning Environment*** - Based on learner inputs
- ***Customized Curricula*** - Based on roles and responsibilities
- ***Customized Learning Path*** - Based on skills assessment
- ***Customized Course Path*** - Based on pre-assessment
- ***Predictive Customization*** - Based on learner behavior
- ***Customized Course*** - Based on needs assessment

In the figure it is also shown that the higher the level of implementation goes, the implementation becomes more difficult.

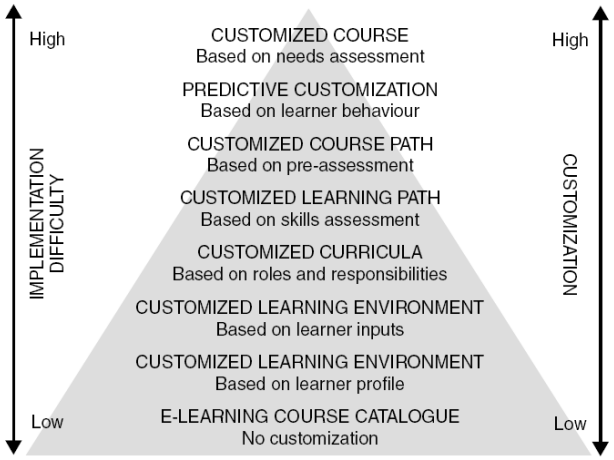

Figure1. The Hierarchy of Customization

2 Modeling: User, Pedagogyand Content Modeling

To know the user means to collect the required information as the user model or the user profiles. Modeling as a primary part in any Information Retrieval System must operate adaptively to the changes of informational requirements. User modeling can be described as the process of forming the user's personal preferences based on his knowledge of his world, behavioral aspects, and interests. In this basis, the student user model consists of the information that reflects his personal knowledge in the domain of learning context. Generally user model includes both **Domain-Dependant-Data** and **Domain-Independent-Data** about the user.

The **Domain-Independent-Data** that is dependant to the context covers the goals and competence that must be obtained by the user, user's knowledge about the context that must be updated by the progress of the time and users knowledge development. The **Domain-Dependant-Data** consists of the Generic Model and the Psychological Model of the student user profile, which are respectively the data collected about cognitive and affective aspects of the student and the data related to the user interests, common knowledge and background (Figure. 2).

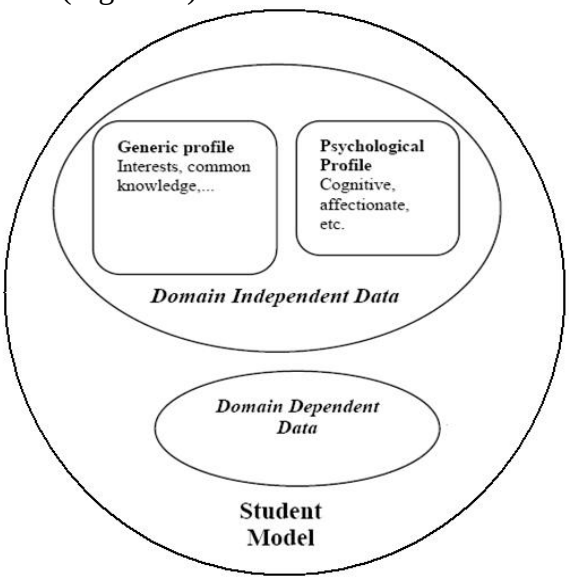

Figure 2. The Student User Model

Since the user model constructs the basis of the adaption and personalization of content and structure, Modeling is so significant in e-learning personalization. There are various ways of user modeling. Some of the main ones are:

Overlay Model: is the most traditional way of representation of user model. In this model the concepts and skills of problem solving and learning are defined as a network of related concepts. The user model may be a network of unstructured concepts, each of which is assigned a value that represents the user's knowledge. The relation between the user knowledge and the domain knowledge concepts is assigned a binary value (known/ unknown), a quality (good, medium, weak) or a quantity (probability of the user acquaintance to the concept).

Keyword-Based Model: In this model the domain knowledge is represented as an array of terms. As the user submits a query, a text filtering is applied to the words in the query and the array. The matches indicate the user's keywords and constructs the model. The model is updated through the progress of time and user's interaction with the e-learning system.

Stereotype Model: In this model a set of default stereotype profiles are considered, and each user can be described by one ar more number of these stereotype profiles.

Pedagogic Model: Since the main goal of e-learning systems is both effective teaching and learning, and this happens when the student "understands" what the teacher teaches. Actually the relation of both sides of learning still continues to be important in e-learning as the ,edia of this relation may affect the fact of "understanding". So as well as knowing the user, knowing the pedagogy of learning must happen for the system nd this could not take place unless a description of the pedagogy is introduced to the system. So the eductional and pedagogy need to be modeled as well as the users. The pedagogy model is defined by two components of **Learning style** and **Teching style**.

Learning style is defined by cognitive, emotional and psychological behaviors, indicating a relatively stable indices of how the student perceives, interacts and reacts to the environment. This behaviors are represented by a set of characteristics and features in e-learning.

Teaching style is defined as the ways that are corresponding to the **Learning style** and through which masters transmit their knowledge to the students.

One popular model in e-learning is the **Felder-Silverman model** in which **Learning styles** and **Teaching styles** are recorded through responses to a number of questions. Responses to questions about the type of information that are best understood such as (auditory, visual, memories, ...), the way that best influence the student's perception (pictures, graphs, words, ...), appropriate information structures that are best understood by students (inductive, deductive, ...), processing methods that are of student's interest (active, passive and ...), and the student progress manner (consecutive stages, suddenly, ...) constitute the **Learning style**. In contrast correcponding answers about teaching such as the type of information emphasized by the professor, methods of offering courses by the professor, organizing methods for presentations provided by the professor, the professor's desired vision of information and ... define the **Teaching style**. The summary of these information results in a table that indicates **Learning style** and **Teaching style** correspondingly and constitutes the pedagogy model of Felder-Silverman.

Another concept that must be modeled in e-learning system due to knowledge representation issues is the learnig content, in order to be adapted and personalized for different users based on their profiles and user models. Content modeling as an important issue in content development, content management and personalization has been standardized speciallyin SCORM (Sharable Content Object Reference Model). The learning content has been studied in SCORM as the course delivery shifted from traditional simple presentation to learning objects. The ***Learning content model*** is derived

by applying the Instructional Design on Educational and Information Technologies. Forexample a course as a learning content is comprised of course objectives, units (lessons, assignments, caed study), research, question bank and references.

3 Recommender systems

Recommender Systems have been highly regarded during the previous decade, especially in the field of e-commerce. These systems in the first stage are designed to reduce complexity of searching and selecting the most appropriate choice that can match the user's information requirements, goals, preferences and interests. Recommender system using different personalization techniques consider different requirement, preferences and demands of users. At the stage of data collection of users model, these systems collect data of users preference through an index called Rating. The Rating can be **explicit** or **implicit**.

1. ***Explicit ratings***. Users are required to explicitly specify their preference for any particular item, usually by indicating their extent of appreciation on 5-point or 7-point likert scales. These scales are then mapped to numeric values, for instance continuous ranges [−1, +1]. Negative values commonly indicate dislike, while positive values express the user's liking.
2. ***Implicit ratings***. Explicit ratings impose additional efforts on users. Garnering preference information from mere observations of user behavior is the method. Typical examples for implicit ratings are purchase data, reading time of content, and browsing behavior like frequency of clicks or areas of clicks. Implicit ratings have its special issues to concern. For instance, in e-commerce some purchases are gifts and thus do not reflect the active user's interests. Moreover, the inference that purchasing implies liking does not always hold.

Using the Rating index ,Recommender systems compute and generate appropriate recommendations through two general paradigms each of that include several techniques and methods. These paradigms are Content-Based Filtering and Collaborative Filtering.
Content-Based Filtering also called the Cognitive Filtering finds the similarities between user preferences with the content and information whis is not yet reviewed or rated. So that establishes a content - content relation between them concerning similar specifications and characteristics. The recommendation is generated and presented according to this similarity relation.
Content-Based Filtering, also called Cognitive Filtering computes similarities between the active user preferences, and content from the whole available content that are still unknown to the uer. content-content similarities are based on features and selected attributes.
Collaborative Filtering, also called Social Filtering, computes similarities between users, based upon their rating profile. Most similar users's positive rated contents then construct the recommendations to the user.
Advanced recommender systems have combined Collaborative and Content-Based Filtering techniques to eliminate the drawbacks of either approach and benefit from their strengthes. These systems are called **Hybrid Systems**.

4 Personalize Recommender systems in e-learning

One of the aspects of learning is the theme of personalized learning. Three issues are involved in the theme:
- First, learning should meet the student individual information and learning needs.

- Second, learning should fit to students' individual learning styles.
- Third, the learning environment continues to adapt and modify its behavior, based on interacting with each student over time.

After getting to know the individual students' background, learning style and learning needs through constructing vaious modelings, now is the time to interact with the learning materials, personal attributes, the learning environment that would provide feedback on the learning materials and create a list of learning materials to the student. These listings of learning material finlly must be dleivered to the right students based on all the system description of their needs and preferences. Therefore, whenever a student expresses his/her learning requests and knowledge background, needed information is presented in a way that takes advantage of the student's learning preferences, and later these discovered preferences are used to recommend the best learning material that woul fit the user's learning requirements and preferences. This type of adaption to the user's preferences and learning requirement and suggesting learners the best fitting learning contents features a personalized learning environment. A personalized learning environment facilitates students to achieve their learning goals by technological supports and suggestions.

Learning recommender systems can be as a personalized learning environment to deliver learning material recommendations to students in a format that best suits an individual student's personal preference, learning experience and requirements. The quality of learning recommendations has an important effect on a student's future learning behavior. Poor recommendations can cause two types of characteristic errors:

- false negatives : Learning materials that are not recommended, and the students still need to study on them.
- false positives : Learning material that are recommended, though the student does not need them.

Other issues such as personalization techniques which can be used in e-learning recommender systems still take into account in this context, but a special aspect of learning that is less concerened in the e-learning erea is the learning style of different students, which is more psychological rather than technical, must be concerned.

5 Learning Styles In E-Learning

Learning styles is an issue of cognitive psychology about processing information, active learning and the structure of information. The learners may prefer a special type of information which can be different from other learners preferences, and may prefer to act or react in his own manner about different learning materials and contents.

Concerning different aspects different kinds of learning style models are distinguished. Four important and well-known ones include :

- ***VAK learning style model*** : this model focuses on human observation channels; vision, hearing and feeling. It is called the Visual-Auditory-Kinesthetic (VAK) model. Based on these observation channels the learning styles are divided into four categories; visual (verbal), visual (non-verbal), auditory and Tactile.this model is based on tha fact that each peron can learn better via a different channel.(Table 1. Describes some equivalant e-learning activities for each learning style)
- ***Kolb's learning style model :*** on a four-stage learning cycle cnostructs the different learning styles in Kolb's learning:
    - Concrete Experience (CE) - feeling
    - Reflective Observation (RO) - watching
    - Abstract Conceptualization (AC) - thinking
    - Active Experimentation (AE) – doing

The combination of two preferred styles defines a learning style also:

- Diverging (CE/RO)
- Assimilating (AC/RO)
- Converging (AC/AE)
- Accommodating (CE/AE)

Based on these stages and the learning styles arised from the combination of stages style, e-learning activity in e-learning system can be designed(Table 2).

- ***Honey and Mumford's learning style model***: it is in some extents similar to Kolb model. It includes four key stages of learning styles:
  - Activist
  - Reflector
  - Theorist
  - Pragmatist

The similarities of Kolb Model and Honey Model cane be shown as these correspondances:

- Activist = Accommodating
- Reflector = Diverging
- Theorist = Assimilating
- Pragmatist = Converging

- ***Felder-Silverman model:*** It focuses on aspects of learning styles on engineering students.

The model has four dimensions. The learning style dimensions according to Felder are:

- sensory/intuitive
- visual/verbal
- active/reflective
- sequential/global.

Again for this model the relative e-learning activities can be recommended to each learing style as the styles above mentioned.

Learning style	Prefers in learning	Recommended e-learning activity
Visual, verbal	Text	E-books, lecture notes, articles.
Visual, non-verbal	Graphics, Tables	Figures, charts, Tables, maps, videos, animations.
Auditory	Sound	Group works, virtual lectures, sound samples, video conferences.
Tactile	Practical related things	3D-models, hands-on tests with specific programs.

Table 1. VAK Learning Style Model

Learning style	Prefers in learning via	Recommended e-learning activity
Diverging (CE/RO)	feeling and watching: watch rather than do	Figures, charts, Tables, maps, videos, animations.
Assimilating (AC/RO)	watching and thinking: clear explanation rather than practical jobs	Figures, charts, Tables, maps, videos, animations.
Converging (AC/AE)	doing and thinking: combine ideas and practice closer together	Simulations, problem solving, quizzes and…
Accommodating	doing and feeling: adapt the learned things into practice	Forums, discussion panels, chatrooms, and team

(CE/AE)		projects

Table 2. Kolb's learning style model

6 Conclusion and Future Works

Inorder to achieve learning goals based on the pedagogical models and other models of user learning requirements, these learning styles in real worls must be introduced to the e-learning enviromnment in a manner that a true correspondance can be defined between actual preferences in real world learning activity to e-learnig activities. As it can be seen in the tables above, it is possible to extract generic activities and information types in e-learning environment that may indicate a specil electronic behavior of the user as the learner's electronic behavior through system's processes' data mining and filtering. These kind of generic behavior indicators if become discovered can result in a kind of e-learning style that can be matched and corresponds to the generic traditional real learning style. In this paper we suggest that recommender system would better recognize such e-behavior in the context, domain and environment of e-learning systems among the learners.

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