Individualized Course on Demand Based on Knowledge Base

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Abstracts Virtual University and distance learning systems worldwide are trying to provide on the Internet online courses that are accessible to anyone, from anywhere, at anytime. In this paper, we propose the course on demand model in our Virtual University Project. The model is based on knowledge base and is intended to produce highly interactive and individual-oriented courses on learners' specific demands. In this model, we define two major types of knowledge units, and establish a response channel and response manipulation mechanism to collect learners' data upon which dynamic content selection can be achieved.

Keywords Knowledge base, response channel, individualized instruction, supervised learning, unsupervised learning.

1. Introduction

We are marching into the era of knowledge economy, in which brainpower will dominate over muscle power, and in which values will mostly be created upon intellectual property. Answering these challenges, it's fundamental as well as urgent to develop the positive attitudes and efficient skills that encourage innovation, artistic analysis and progressive problem solving. In order to do this, we must enforce in-depth reforms in education, reforms that will replace conventional on-campus, face-to-face, time-and-place-confined-education with free, flexible and multimedia-based learning system, most important, this system must be open and individual-oriented.

Building distance learning system and virtual university (called VU) has been a hot issue in the last ten years. So far, many works have been presented. Typical ones among them are:

- Virtual-U Research Project developed by Simon Fraser University;
- Virtual College of New York University;
- FBSD Virtual University;
- Global Virtual University;
- Virtual University Project in Korea.

But still, there is no generally accepted model of distance learning system that is powerful and efficient enough for course delivery. The disadvantages of the conventional VU are:

- interactivity level with learners is rather shallow, and is not in a continuous manner;
- courses are delivered in static and massive-oriented manner;
- course delivery does not take into account of individual learning factors and psychological factors.

We therefore intent to develop an interactive, dynamically delivered as well as personalized education system by applying the state-of-the-art technologies in high-speed network, massive scale database, multimedia deliver and intelligent software agent.

We will make the Virtual University an educating and learning environment that can be customized to specific learners' requirements, with this middle-ware strategy in mind, we're intending to provide a range of supporting tools including:

- Management tools;
- Presentation tools;
- Monitor tools;
- Resource classification tools;
- Knowledge assemble and disassemble tools;
- Response collection tools (channel tools).

In the rest of the paper, we outline our system in Section 2, and propose the knowledge base and achieving individualized instruction based on the knowledge base in Section 3. Response channel and manipulation system and their implementation are discussed in Section 5 and Section 6, respectively.

2. Outline of Course on Demand System

2.1 Virtual University Components

The skeleton of VU components mainly compose of three modules:

① Knowledge base;
② Response channel and manipulation system interface level;
③ Content assembly mechanism.

Figure 1 is the logical level of these three modules.

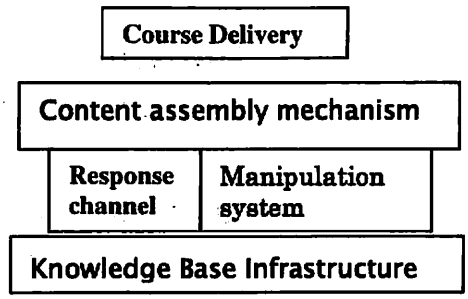

Figure 1

2.2 Defining Learner Types

We define the divergent types of a learner into mainly six classes:

① learners who like to explore and search (strategically) through the environment;
② active learners who are keen to engage in interaction with and manipulation of the exploration;
③ intentionally learners who willingly try to achieve cognitive objectives;
④ conversational learners who enjoy engaging in dialogue with other learners and with instructional systems;
⑤ reflective learners who are ardent to articulate what they have learned and reflect on the procedure and decisions inherent in the learning process;
⑥ implicative learners who are fond of generating assumptions, attributes and implications of what they learn.

2.3 Defining Capability Types

We're trying to avoid making the Virtual University into an "information-dissemination-oriented" learning environment, we focus pedagogical instruction and content delivery strategy on the entire process of learning, especially on how to create and organize knowledge, how to digitalize knowledge, as well as how to construct comprehension. We will demonstrate these strategies in mainly two learning styles:

supervised and unsupervised learning.

1) *Supervised learning*

In supervised model, we'll incorporate several kinds of instructional strategies in the form of intelligent agents. On the basis of response collection and response handling, the response data from learner will become the supplementary and tuning parameters of the pre-settled instructional strategies.

We mainly adopt the following instructional strategies:

1) case-based learning;
2) problem-based learning;
3) reward-based learning.

In supervised model, prior to the beginning of a specific learning process, the VU system will negotiate with the learner in terms of:

1. learning objective;
2. parameter and definition of interactivity;
   - interaction interface;
   - interaction frequency;
   - response timing;
3. control level;
4. delivery inclination.

2) *Unsupervised learning*

In unsupervised model, learner learns by an active exploration through the Knowledge Base (KB) by him-or-herself. The VU educating system will provide pertinent functions supporting this intelligent exploration. The functions include:

❶ Providing multifarious representation and presentation forms of the relationships between KUs (Knowledge Units).

❷ Different directing strategies for exploring through the KB.

- Question-driven directing strategy
- Object-driven directing strategy
- Region-driven directing strategy
- Relation-driven directing strategy
- Level-driven directing strategy
- Tendency-driven directing

In setting up their own sub knowledge base and cognition context, learners will possess with different capabilities, for example:

- logical abilities;
- verbal abilities;
- cognitive abilities;
- imagination abilities;
- management abilities;
- observation abilities;
- memory ability;
- writing, description, presentation abilities.

3. Knowledge Base

3.1 Structure of Knowledge Base

Knowledge Base consists of two parts:

- General knowledge base
- Special knowledge base

We define a Knowledge Unit (KU) as anything that's meaningful, and relatively independent as well as self-contained knowledge object. KU can refer to concept, behavior, function, relationship alike.

Actually, we define only two types of KU:

- Concept type
- Relationship type

Concept Type KU represents any class of knowledge object and its instances that is concept-derived; while Relationship Type represents the interaction and connection methods between KUs.

The concept type KU contains relatively static information, it depicts the status, conditions

and features of a KU which shall be static for a certain period of time, it will describe the specific concept in terms of its name, attributes, methods, descriptions, extension points, etc. The relationship type Ku contains relatively dynamic information, it depicts the interaction, influence effect, relating ways between KUs, it will define as many as possible whatever relationships there are between KUs. The relationships between concepts can be represented in many ways as:

❶ Circuit-switch connection

The relationship between any pair of concepts is one-to-one. This type is typically used for concept definition.

❷ Bus-type connection

In this scheme, the description of the mainline (the bus) will link several or many different concepts into together. The bus has two open ends, which means it's free to add or remove concepts on the bus. This type is typically used for knowledge retrieval.

❸ Route-table connection

This scheme is highly similar to network routing table.

Apart from classifying the various relationships among KUs, we define supplementary properties for each relationship.

① Solidity property

Describes how close are the two KUs related with each other.

② Time to last property

Describes how long will a relationship last.

③ Degree property

Describes how deep a relationship can be.

④ Cost property

Describes when connecting two KUs, in case direct relationship is absent, how many concept relay paths need to be setup.

Any given piece of knowledge is multi-dimensional, this means the knowledge should have multifarious representation forms, presentation forms and semantic forms at different levels and different directions, that is why the same piece of knowledge appears so differently in the eyes of different observers. Using multimedia, a Ku can be represented and presented in either of the following forms:

① text ;
② audio ;
③ still images;
④ graphics;
⑤ animation;
⑥ video;
⑦ virtual reality.

And there can be hundreds of thousands ways to represent a Ku by combining the above single media forms into a complex and semantically cohesive form.

3.2 Achieving Individualized Instruction

❶ The knowledge unit will be arranged on many levels, from comparably low levels to pretty high levels (level criteria can be customized). Each knowledge unit will be the entity integrating multimedia-derived presentation and object-oriented semantics.

❷ The knowledge unit will also be presented in multimedia, in many ways, from many different view points, which means the knowledge presentation may span across many disciplines.

❸ For each time's content delivery, the whole learning process will be set in an virtual social context, the delivery methods will be combining with the (ultimate) learning goals which will do with learning to use, and learning to practice.

❹ Tailor course content on the basis of the data gathered from the response channels and response manipulation system.

❺ Learners use presentation tools to illustrate their responses and comments in a concise and convenient way.

❻ The course content will be supported in the background by a comprehensive knowledge Base (KB)---which is relatively static and is the infrastructure of the uniform education platform, and a Supplementary Information Base (SIB) which holds the accumulated online response and comments from learners. After a certain time period, the content in SIB may be absorbed into KB after being authenticated.

❼ Construct the backbone of knowledge base, publish the imperative rules for adding knowledge content, presentation and inter-connection, on this basis, the *Knowledge Internet* can be formed.

❽ Construct the (Knowledge) Content Authorization and Authentication Center to handle and certify Content Update Proposal.

4. Response Channel and Manipulation System

Establishing response channels and response manipulation system to ensure in-depth and efficient interactions with learners is the critical part of implementing VU, and is also the critical part of realizing individualized education.

Response channels will collect, track, analyze and monitor learners' responses and comments in the first time. Upon the data accumulated, the kernel control/switch agency in the Response Manipulation System will be able to deliver (finely) customized course content to specific learners and to specific learners' requirements.

The Response Channels can get learner's response in the following ways:

- learner asks question(s) about particular knowledge points
- learner engages into public communication area
- learner involves in private communication dialogue
- learner's active or passive response
- learner's comments
- learning speed and period
- content's level span
- learning objectives

The response channel will be the signaling sub-net over the Knowledge Base. Upon this, we define interactivity between educating system and learners in two general ways:

① Active response-derived interactivity

② Passive response-derived interactivity

And we distinguish two styles of interactive message:

① Probing message

② Response message

By combining the above mentioned interactive modes and message types on both Server side (education system) and Client side (learner) we therefore further define the interaction process into the following models:

Let: S denotes Server side, C denotes Client side;

A denotes Active, P denotes Passive;

Pr denotes probing message, Res denotes response message;

The interaction type can be classified into eight models:

1 (S, A, Pr) ←--→ (C, A, Res)

2 (S, A, Pr) ←--→ (C, P, Res)
3 (S, P, Pr) ←--→ (C, A, Res)
4 (S, P, Pr) ←--→ (C, P, Res)
5 (C, A, Pr) ←--→ (S, A, Res)
6 (C, A, Pr) ←--→ (S, P, Res)
7 (C, P, Pr) ←--→ (S, A, Res)
8 (C, P, Pr) ←--→ (S, P, Res)

Here, notation "(S, A, Pr) ←--→ (C, A, Res)" means that the server site actively sends probing messages and the client site actively response that. Other notations could be read similarly.

5. Implementation of Response Channel and Content Assembly

We implement the response channel and content assembly mechanism by three inter-dependent components: *Content Directing Strategy, Media Integration Management and Synchronization Protocol.* Synchronization protocol is responsible to coordinate the presentation sequences and media streams of the content retrieved from KB. It guarantees both the physical transmission and logical relationships among streams.

Further, the Content Directing Strategy, Media Integration Management components are implemented by three interleaved function bases:

- Preparation
- General Service
- Specific Service

Preparation function mainly performs the following tasks:

- Collect students personal information
- Establish Student database
- Initially modify course page

General Service function mainly perform the following tasks:

- change background music
- modify course level
- modify course position
- enter into simulation mode
- enter into collaboration mode

Specific Service function mainly perform the following tasks:

- Media selection
- Synchronous mode selection
- Automation mode selection
- QoS selection
- Search for virtual knowledge unit

6. Conclusion

In this paper, we propose a new approach for Course on Demand system. In the future, we plan to make detail design and implement the system.

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