CHAPTER 7

INTELLIGENT TUTORING SYSTEMS

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7.1 INTRODUCTION

Artificial Intelligence (AI) is a vital link in the movement towards multimedia education and training. AI techniques enhance the power of simulation and hypermedia by enabling the system to perform more complex tasks effectively. Prior to 1982, teaching by computer was relegated to the field commonly known as Computer Aided Instruction (CAI)[6]. Intelligent Tutoring Systems (ITS) are basically a Knowledge Based System for teaching and training that is responsive to the learner's needs and understands their knowledge/skill level.

The goal of Intelligent Tutoring System is to assist users and individuals with diagnostic and pedagogic capabilities approaching that of a human tutor. Such tutoring can be effective because the tutor can respond to the specific needs of a user, guide slow learners, challenge rapid learners, and monitor the progress of each user at a time.

Since expertise is very rare and not easily available every time, the tutoring cum advising system can be planned for effective teaching and training through use of Information Technology. High quality of knowledge is needed to give stepwise assistance and learning in a technical field. In remote areas, expertise is rare and outside experts may not be aware of environmental effects as well as the mentality of the population in the area. In such situations, an intelligent system can be trained with important attributes and characteristics of the surrounding environment to work more effectively.

7.2 FEATURES AND BENEFITS

Some of the important features for tutoring can be given as follows:

- User modeler, which is an analytical facility to understand knowledge/skills of users through their responses
- Expert module, which possesses detailed domain-specific knowledge and curriculum information. This unit works as a foundation for teaching
- Tutoring scheme, which is enriched by tutoring models, schemes for different levels of users: for slow, average, and fast learners
Such tutoring systems provide an automatic facility of individual user instruction for large target audience. The major benefits are as follows:

- Explanation and reasoning for decisions taken beside the good representation, teaching and monitoring functions and/or facilities
- Multiplicability and repeatability of the systems
- Handling and monitoring different levels of users at a time and to provide an automated means for remote and simultaneous education, presentation and instructions to large audience
- Self evaluation for user is easy, fast and accurate
- Well updated question bank and supplementary learning materials in multimedia
- An additional facility of the natural language front-end on request
- Identifying the weak areas of individual and highlight them
- Better user control, flexibility and timeliness
- Efficient storage and documentation of the domain knowledge

Such systems may use the audio, video, text, graph and animations to dynamically represent and explain the things and presents a real life view. Structure of the multimedia user database defined earlier in Chapter 6 of this thesis may be considered here. As stated earlier, AI techniques enhance the power of simulation and multimedia by enabling systems to reason about what to present next and how best to represent it for effective tutoring. The major components of the system are knowledge base, inference engine, user interface (which may be multimedia), explanation, reasoning and self-learning modules. In addition a database can be attached as a temporary workspace and a repository of question banks, users data and other related documents.

If necessary, to avoid complexity of the system and to increase modularity, one can divide the knowledge base contents in different clusters/levels depending on their knowledge type, representation scheme and frequency of need[3].
7.3 CATEGORIES OF KNOWLEDGE

There are four major categories of knowledge exist in the knowledge base of the ITS viz.:

1. Knowledge about domain
2. Knowledge about knowledge (meta knowledge)
3. Knowledge about learner
4. Knowledge about process

7.3.1 Knowledge about Domain:

The knowledge about domain contains specific factual knowledge of the area, different procedural rules with their Certainty Factors (CF) and intelligent heuristic functions for making decision regarding representation of knowledge, assessment of users and evaluation of users. Declarative and procedural knowledge can be separated if multi layer KBS is used as a base architecture.

7.3.2 Knowledge about Learner:

By analyzing responses by users at different stages, knowledge level can be evaluated. Alternatively, from question bank of the related topic one or more quizzes will be prepared and according to its result, percentage level can be determined. An example of an heuristic function, which determine the level of user (L_Level) depending on his quiz marks (Q) and speed-correctness ratio (S/C) is given below.

\[
\begin{align*}
L\_\text{Level} &= \text{High} \quad \text{if } Q \geq t1 \text{ and } S/C \leq x \text{ question per minute(qpm)} \\
&= \text{Medium} \quad \text{if } t2 \leq Q \leq t3 \text{ and } S/C = y \text{ qpm} \\
&= \text{Low} \quad \text{elsewhere}
\end{align*}
\]

According to the responses of the user, his liking/priority about the given media like graphics, animation etc. can be calculated and next representation scheme can be chosen. Responses of the user, history and temporary results can be stored here too.
7.3.3 Knowledge about Knowledge:

Knowledge about knowledge with its corresponding media and its representing scheme can be one of the prime candidates of the meta knowledge of a knowledge base. For example, if semantic links are used to represent knowledge, the Table 7.1 describes the possible example links to be available as meta knowledge.

<table>
<thead>
<tr>
<th>Link Type</th>
<th>Synonyms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is a part of</td>
<td>Synonyms are: segment, portion</td>
</tr>
<tr>
<td>Is a type of</td>
<td>Synonyms are: example, kind, and category</td>
</tr>
<tr>
<td>Leads to</td>
<td>Synonyms are: causes, result in</td>
</tr>
<tr>
<td>Has Property</td>
<td>Synonyms are: an attribute of,</td>
</tr>
<tr>
<td>Is a Property of</td>
<td>Synonyms is: a characteristic of</td>
</tr>
</tbody>
</table>

Table 7.1: Knowledge about Knowledge: Examples of Links

7.3.4 Knowledge about Process:

Different teaching schemes and models can be stored here. Models and schemes along with a level indicator will be more helpful in selection process. One such model is operational learning model. The basic learning processes are acquiring of knowledge, validating it against existing knowledge for contradiction and/or duplication, integrating it with existing knowledge and testing in a new application before final application and adoption. The processes can be visualized as in Figure 7.1A.
The basic processes involved in the system include knowledge management, representation and evaluation of performance. Table 7.2 enlists the different major processes involved in the ITS with its description. The knowledge management contains sub processes like
acquire, integrate and test. New knowledge can be inferred or learned during the execution of the system. This must be tested against the existing knowledge for duplication and/or contradiction. For better and effective usage, the new knowledge must be integrated with existing concepts/knowledge. They both together are candidates of testing process. Important quality control measures can be planned and examined at these processes. Table 7.2 lists the core processes of the system and Table 7.3 gives list of the major data/knowledge entities in the system.

<table>
<thead>
<tr>
<th>Process</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquisition of new knowledge</td>
<td>Acquiring new knowledge by self learning from process or from users</td>
</tr>
<tr>
<td>Application</td>
<td>Identifying the application and using the existing knowledge</td>
</tr>
<tr>
<td>Documentation</td>
<td>Knowledge and users data in a printable format for documentation purpose</td>
</tr>
<tr>
<td>Interaction</td>
<td>Enhanced interaction preferably in users own language and media of choice</td>
</tr>
<tr>
<td>Integration of new knowledge &amp; adopting</td>
<td>Integrating new knowledge chunks with existing concepts and facts.</td>
</tr>
<tr>
<td>Meta knowledge updation</td>
<td>Updating the knowledge about knowledge</td>
</tr>
<tr>
<td>Monitoring</td>
<td>Monitoring the users responses and performance</td>
</tr>
<tr>
<td>Quality Control</td>
<td>Intelligent methods for better quality, quality metrix etc.</td>
</tr>
<tr>
<td>Reporting</td>
<td>Summary report for one or more users response, performance and level of learning</td>
</tr>
<tr>
<td>Representation design</td>
<td>Selecting media to effectively represent the theme.</td>
</tr>
<tr>
<td></td>
<td>Sequencing of the knowledge for better representation</td>
</tr>
</tbody>
</table>
(Table 7.2 Contd.)

<table>
<thead>
<tr>
<th>Processes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response information collection</td>
<td>Accepting responses from users which might be in their own language</td>
</tr>
<tr>
<td></td>
<td>Editing and recording responses</td>
</tr>
<tr>
<td>Response evaluation</td>
<td>Evaluating users response(s) to select the next presentation and its media</td>
</tr>
<tr>
<td>Test &amp; Validate</td>
<td>Test the new knowledge chunks against existing knowledge for duplication and/or contradiction using some filtering heuristics</td>
</tr>
</tbody>
</table>

Table 7.2 : List of Some Core Processes in the System

<table>
<thead>
<tr>
<th>Entities</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domain knowledge</td>
<td>Extensive domain knowledge and its representation, target users etc.</td>
</tr>
<tr>
<td>External data</td>
<td>Consists of all important entities outside the environment like users information, curriculum knowledge, reference and source information, Govt. Policy</td>
</tr>
<tr>
<td>Help &amp; Documentation</td>
<td>Information about logging in and out, Navigating through different menus, trying sample transaction etc.</td>
</tr>
<tr>
<td>History data</td>
<td>History about users information and their responses</td>
</tr>
<tr>
<td></td>
<td>History about knowledge update etc.</td>
</tr>
<tr>
<td>Other Internal knowledge &amp; data</td>
<td>Meta knowledge, process knowledge, report layouts, knowledge about representation schemes etc.</td>
</tr>
<tr>
<td>Strategic Plan</td>
<td>Include objectives, goals &amp; mission statement, action plan etc.</td>
</tr>
</tbody>
</table>

Table 7.3 : List of Some Core Data/Knowledge Entities in the System
7.4 OBJECT MODEL OF THE SYSTEM

A knowledge piece can be considered as an object, which possesses the links as different interfaces/processes as shown in Figure 7.2. ‘Is a part of’, ‘Leads to’, ‘Is a type of’, etc. would be the proper interfaces to interact with the desired knowledge piece. In addition, a knowledge piece can be related with other knowledge pieces with the appropriate link or class definition. So whenever it is necessary to refer another knowledge piece, the link can be used.

![Figure 7.2: A Knowledge Object at Conceptual Level](image)

7.4.1 Inheritance & Classes formation:

The related knowledge objects can form a class, which can inherit other subclasses and act as a super class for the inherited classes. New classes can be generated as a result of self-learning process.

7.4.2 Encapsulation:

The knowledge stored in an object form can be stored by any suitable knowledge representation technique, but it would be made available through proper links and interfaces only. This feature gives an extra security at the very basic level, in the knowledge base itself.
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7.4.3 Polymorphism:

An object can be thought as and represented in many different ways accordingly to the need and level of user. This increases its reusability and amount of access in more appropriate way resulting increase in its cost benefit ratio.

7.5 APPLICATIONS

7.5.1 Health Awareness:

ITS in remote areas can be used to make local people aware about the climatic and environmental conditions and basic rules of sanitation. The system may effectively represent the cause and effect of various diseases on human beings. The system, in addition, can generate the list of precautions, information about diseases and their remedies in different media. Figure 7.3 visualizes this situation pictorially. Other areas regarding the human sanitation are Pregnancy, Childcare & Brought up, etc. Many diseases can lead to serious social and medical problems affecting the whole world. There is no solution to the threats they pose. Intelligent Tutoring System may provide awareness for the same.

The same system can be used to identify and/or generate knowledge and awareness about the vegetables and crop diseases and animal husbandry.

Health Management Through ITS:

Successful health management requires a proper balance of health key items such as diet, stress management, physical exercise and on and off work activities. ITS can assists beneficiaries by providing a personal health analysis and a health management plan. By nature ITS has an ability to accept users response, posses doctors' knowledge and mimic their complex inference processes. See Figure 7.4 for description.

7.5.2 Technical Education:

Depending on the availability of the capital investment, environmental conditions and level of user such system can be used as an effective teacher of technical subjects. The audiovisual clippings of the knowledge assist the users to grasp the subject in very practical way. Actual practical need not to be carried out by the user.
Figure 7.3: Objects at Conceptual Level

Figure 7.4: Health Management System

Evaluation Data
- History of patients
  - Illness
- Past medical history
- Family history
- Social history
- Physical fitness data

Medical Knowledge Base
- Health diagnosis
- Life style
- Diet
- Disease risk evaluation

Fuzzy Interface Unit

Personal Health Management Plan:
7.5.3 Primary Education/Adult Education:
The system can be useful in educating the adults for their primary education. Letters, pictures and grammar formation can be very well explained in conjunctions with the day to day events of the concern area. Assessment of users and special help to slow learners can be made possible through the tutoring system.

7.5.4 Education for Mentally Retarded:
Like anyone else, the handicapped need the opportunity to prove themselves and the opportunity to make a meaningful contribution to the society in which they live. 10% of the India's population is disabled[1]. The computer can be effectively used even by mentally retarded besides other handicapped person[5]. Intelligent tutoring System with multi media may help children and adults having multiple disabilities to learn many things with fun. This may leads to change in the traditional input and output systems according to the kind and degree of the disabilities.

7.5.5 Social Issues:
Special learning schemes can be introduced for the objective of uplift of poor, women and economically backward class people in remote areas through an intelligent tutoring system.

7.6 CONCLUSION
Individualized instruction by a competent tutor has been proven to be far superior to classroom style learning. Computer Aided Instructions with intelligence and multimedia facility gives advantages of intelligence, multimedia and object orientation. There are some key issues that need to be addressed by any system for training purpose, for example,

- Effectiveness of fresh users training
- Effectiveness of middle level training
- Long term sustainability
- Cost effectiveness
etc.

All though intelligent Tutoring Systems have been proven to be highly effective learning aids, they are time consuming, difficult and expensive to build. That is, such system must have high cost-effectiveness ratio after successful implementation. To increase the same, one must
increase the usage and effectiveness of the system. As stated above, such systems are more effective, usage can be increased with proper planing and development strategy keeping the idea of reusability in mind. Since the proposed structure is using Object Oriented Approach, the reusable design approach discussed in Chapter 5 of this thesis, can be very well applied here.

The another alternative is to develop a KBS shell in comparatively cheap PC environment. Teaching system that attracts people has obvious and immediate advantages over other non-attractive teaching tools. Using the Internet, such system can store widely available encyclopedias of information accessible through networks.
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7.7 REFERENCES


