Development of Agent-Based Intelligent Tutoring System for Teaching Object-Oriented Programming Concepts

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ABSTRACT

Agent-based technology can be used in developing educational tutoring systems. An Intelligent Tutoring System, named as 'ProgTool' has been developed for teaching object-oriented programming concepts. The 'Prog-Tool' has been developed using JADE (Java Agents Development Environment) framework. This system helps the students to learn about Objects, Classes and other programming concepts by taking tutorials from it sitting anywhere and anytime. This paper shows that usage of 'Prog-Tool' helps students with topic sequencing, visual representation, and choice of multiple exercises and tests on each topic makes it a very useful for students.

Key Words: Software Agents, JADE, Object-Oriented Programming Languages, Intelligent Tutoring System.

1. INTRODUCTION

Intelligent tutoring system is a computer system that has the ability to provide individualized instructions or feedback to students without the intervention of human tutor [3][5] [6][9]. These have emerged from the application of artificial intelligent system to computer-based instruction system [8]. Intelligent tutoring systems fully embody the problem in the field of education. The key feature of intelligent tutoring systems is the ability to provide a user self-adapted presentation of the teaching material by using artificial intelligence methods to represent the pedagogical decisions and the information to each user.

Agent-based intelligent tutoring systems are built using agent-based technology. Agents are program that can work intelligently to fulfil the needs of intelligent applications. The approach of using agents in intelligent tutoring system has been emphasized in the last decade. The agents used for making intelligent tutoring system are known as pedagogical agents. The main reason for inclusion of pedagogical agents is their capability of communication and interaction. The fundamental properties of these agents are autonomous, social ability, pro-activeness and persistence students [4].

Object and Classes are the fundamentals of object oriented programming. Most of the students are not able to grasp its concepts including object-oriented approaches and parameters passing easily. They need help of human tutors repeatedly who cannot teach each and every student individually. To make it easy for students to learn programming languages including C++, BASIC, FORTRAN and Java in a practical manner, various traditional tutoring systems with agent-based technology have been developed[7][8]. These systems have different-different modules whose basic function is to compare the students' answers with domain knowledge base. Hence, in this way, these systems evaluate the performance of students and decide the corrective actions for improving their knowledge [2].

Intelligent Agent-based tutoring can be developed using various frameworks. The purpose of this research is to develop Agent-based Intelligent Tutoring System, named as 'ProgTool' for teaching object oriented programming concepts using JADE [1]. JADE is Java Agent Development Framework. It is a framework which is implemented in Java language. It enables the implementation of multi-agent systems. This follows FIPA (The Foundation for Intelligent Physical Agents) specifications. It also provides a set of graphical tools for debugging [1]. There have been developed about four agents which work integratedly. These are pedagogical expert agent, tutoring agent, student agent and feedback agent. These agents work collaboratively to support the pedagogical activites. In this research paper, description about how we have developed intelligent agent-based tutoring system for object oriented programming concepts.

Th tutoring system provides the students opprtunity to learn various concepts of object-oriented programming one by one. These conepts are organised in a logical manner. Student are only allow to learn a concept if he/she fulfils the prerequisite. It means students need to finish previous topics first. It gives the student study material in textual and diagramatic form. It is said that students learn by practice. Student's knowledge is checked by asking questions after the students read the whole topic. If a student gives correct answers of all the questions, his status is updated into the database. New topics are made available to him/her. Hence, it can be said system teaches students very efficiently and step-by-step.

2. SYSTEM ARCHITECTURE

'ProgTool' has been designed to individualize the students learning process. This system provides instructions to the students in an individualized manner. The architecture of the system is divided into three layers: Knowledge Base Layer, Agent Layer and User Interface Layer.

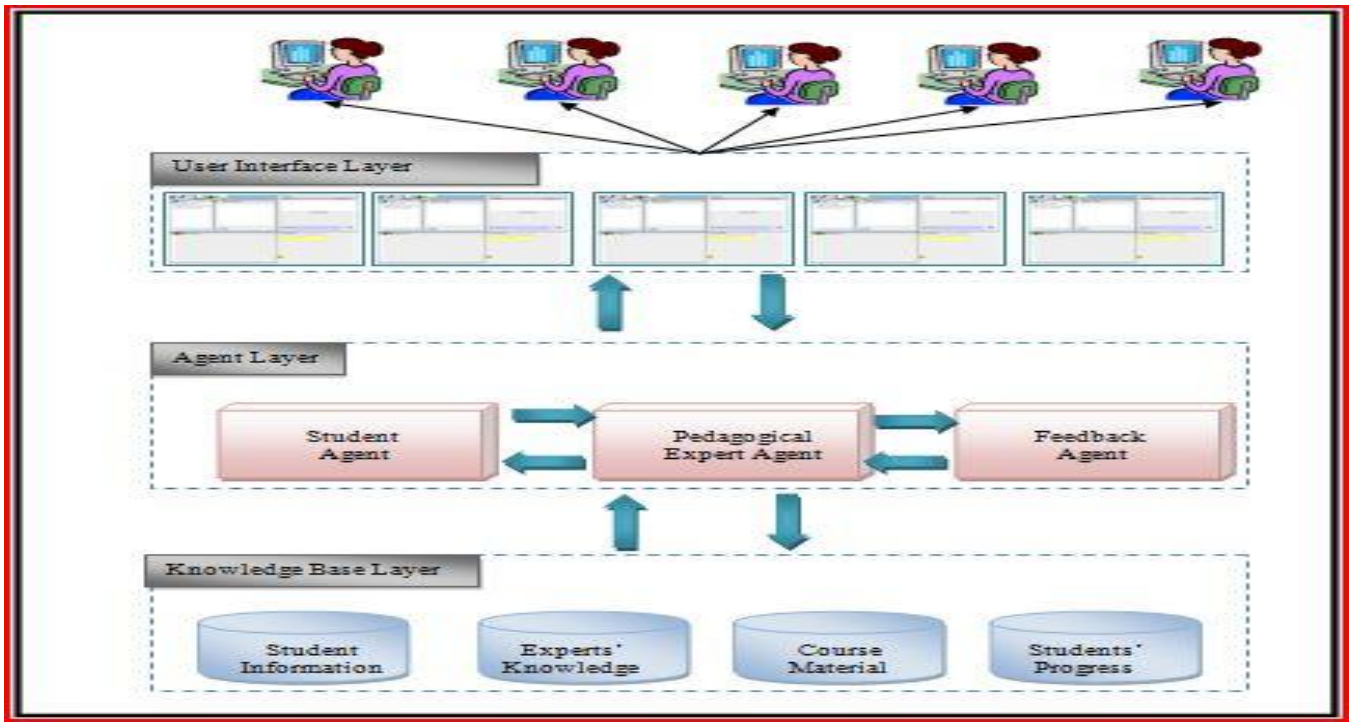


Figure 1 Architecture of the Agent based Intelligent Tutoring System

Knowledge Base Layer

Knowledge base layer stores students' related information such as demographic information, and their level of knowledge related to the subject (Students' progress). This also stores experts' knowledge and information about course material and structure of the course. System analyses the students' current state of knowledge by comparing it with the experts' knowledge. Based on analysis, this system gives students material to read for improving their knowledge. Information such as what topics students can access is also stored into the knowledge base. The system also stores students' progress into its knowledge base.

Agent Layer

This layer contains agents which react intelligently based on the action performed by user and information stored in the knowledge base layer or database. There are three agents in this layer:

Pedagogical Expert Agent: This agent is responsible for giving information to the student in a logical manner. This course is divided into topics. List of topics which the system will teach to the students in the course are shown in the system. This agent allows the students to read only those topics for which they fulfil the criteria. This gives information to the students in textual and diagrammatic forms. After each topic, test is given to students. Students' performance is checked with some criteria. If they really perform well in the examination, system will congratulate to the students and allow them to study next topic. They are given some questions to answer in the tests related to the readings and diagrams shown to the students. These questions are of objective types. Each is having four options. Out of which only one option is true. Hence, in this way, it can be said that this agent helps the students enhance their knowledge logically.

Student Agent: Student agent is the agent which obtains information about student's progress. Students' progress information is stored into knowledge base to compare it with the experts' knowledge stored in the knowledge base. After comparison between students' and experts' knowledge, it finds whether the student is able to read the next chapter or not.

Feedback Agent: Feedback agent of the system is the second most significant agent of 'ProgTool' after pedagogical expert agent. Proper feedback timing and style are important for the effectiveness of the system. Timing means when the student is given a response to the solution. When the feedback is presented to the students should be governed by what the students have done [8]. Hence, feedback agent was given very high consideration. Students are given proper feedback for whatever they do with the system. This increases the usability of the system. They are given both visual and textual feedback.

User Interface Layer

User interface layer is the layer which contains user interface. User actually interacts with the system through a Graphical User Interface developed in Java. This graphical user interface connects user with agent system which serves the requests of the users very intelligently. Graphical user interface gets the information from the agent layer. However, agents layer itself gets the information from the database layer. Therefore, it can be said that user interface cannot access database directly however, it accesses the database through agents' layer. Therefore, in this way, it becomes the system more secure.

3. IMPLEMENTATION OF PROGTOOL

Implementation using JADE: JADE is Java based software. Java is a platform independent programming language. JADE provides programmers a framework which is a kind of middleware built by TILAB for developing distributed multi-agent applications. This is a peer-to-peer communication architecture which is the basis of distributed multi-agent applications. Peers are agents in the system

which can be distributed at various computers. Agents developed with JADE are able to work dynamically according to the needs of the system. They can appear and disappear according to the requirements.

Architecture of JADE is fully suited for the development of agent-based intelligent tutoring system. Agents in the system are known as pedagogical agents. There can be tutoring agents, feedbacks agents and student agents. Every agent works as an autonomous module which acts like an intelligent peer. They also communicate with each other. Moreover, every agent does not work all the time necessarily. They appear according to the requirement of the system [1]. Hence, when there is no need of some agent, that agent do not perform any activity.

Working of User Interface: User interface of agent based intelligent tutoring system is very important aspect that has been given a careful consideration during the design of the tutor. In beginning of the execution of the system, a login module is displayed. This module asks the user about login information. This information helps the system to recognize the students. This shows contents to student based on their profile stored into the knowledge base. If the student is a new user, he will have to register first. After registration process, he/she is provided student id. Using the student id and password, new user can login. After login into the system, 'ProgTool' screen is opened (see figure 2). This screen is divided into seven sections. First section is menu bar. There are four menu items on the menu bar such as File, Navigation, Windows, and Help. Student can find lots of item in the menu items that he/she can use to operate the application.

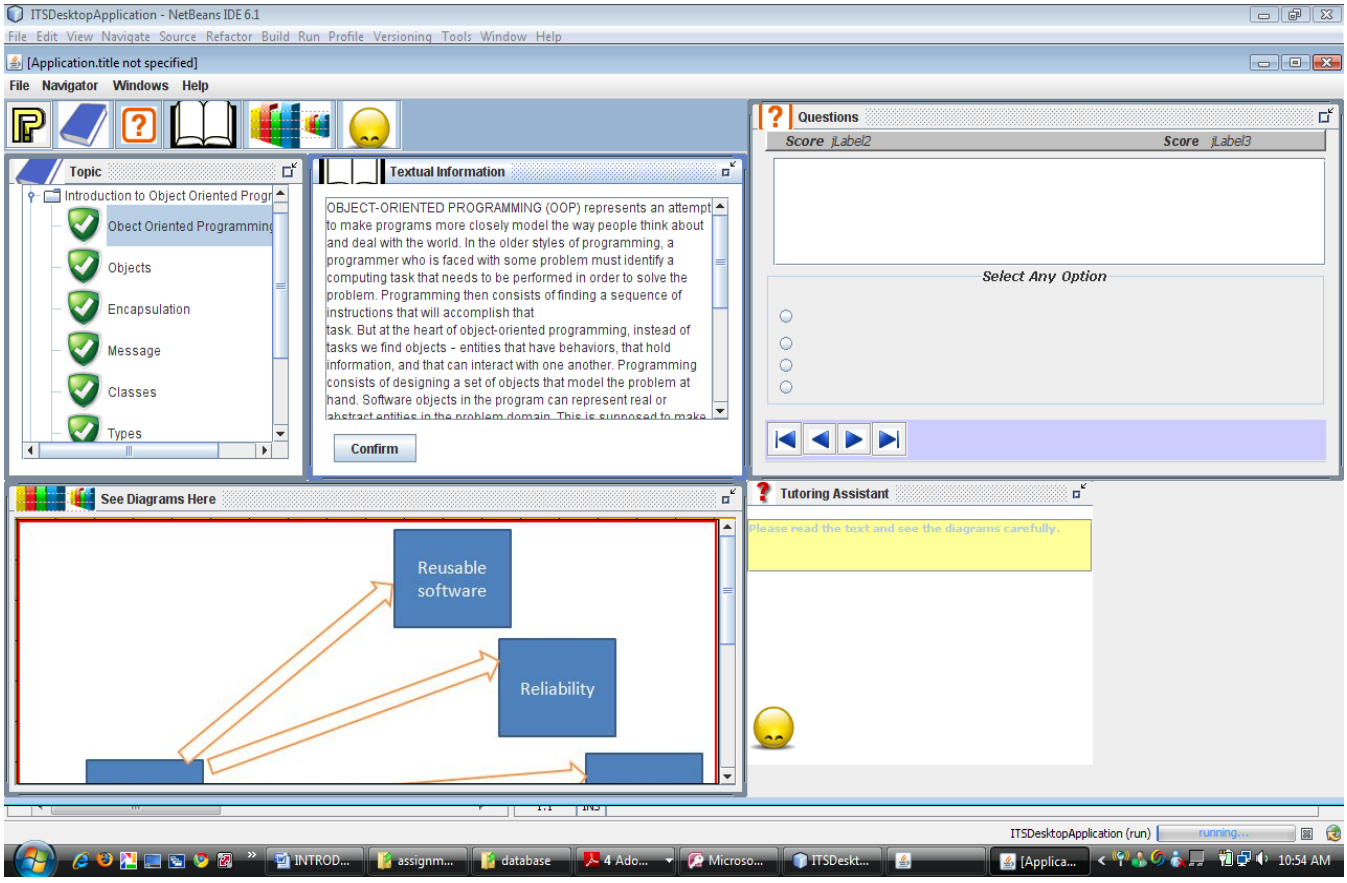


Figure 2 ProgTool Window

The next section is toolbar section. There are five icons representing the five boxes in the system such as Topic box, Textual Information Box, Question Box, See Diagram Here Box and Tutoring Assistant Box. Student can show and hide any box according to their needs. This toolbar is really helping the system to increase its usability.

During the login process, when system displays the 'ProgTool' window, system opens the five boxes straightway. During the login process, system recognizes the user; it retrieves the information about the user from the database. After the recognition of the user, system switches on the pedagogical expert module automatically. This agent retrieves the information about the students' current progress status from the knowledge base. Then it displays the topics in the topic window. It only activates those topics for which user have already qualified. Rest of the topics will be only shown to the user, but they will be deactivated. When a user wants to read a topic, he/she chooses the topic first. Pedagogical expert agent checks the option selected by the user. It then checks whether the users have qualified the criteria for studying this topic. If yes, it shows the information to the user in the form of text in the 'Textual Information Box' and diagrammatic information in the 'See Diagram Here Box'. Whenever, user clicks the 'Confirm' button on the 'Textual Information Box', it sends the message to the pedagogical agent that user have already read and see the diagram carefully. Pedagogical agent gives the user a test to examine his knowledge. If the user performs really well, it updates the status of students' knowledge in the database (knowledge base). For updating the status of students' knowledge in the knowledge base, a pedagogical agent sends a message to student agent. This student agent is used to keep track and update the status of user's current knowledge in the database.

Whenever a user gives the test to the system about a topic, feedback agent checks the user's answers and gives him/her immediate feedback. It tells him/her whether the selected option is wrong or right. Moreover, feedback agent sends instant message to display the text saying selected option is right or wrong in 'Tutoring Assistant' box. At the end, when user completes the test, it tells him/her if he/she has qualified for the next section or not. Below is given the flow chart (see figure 3), that explains that how information flow into the system.

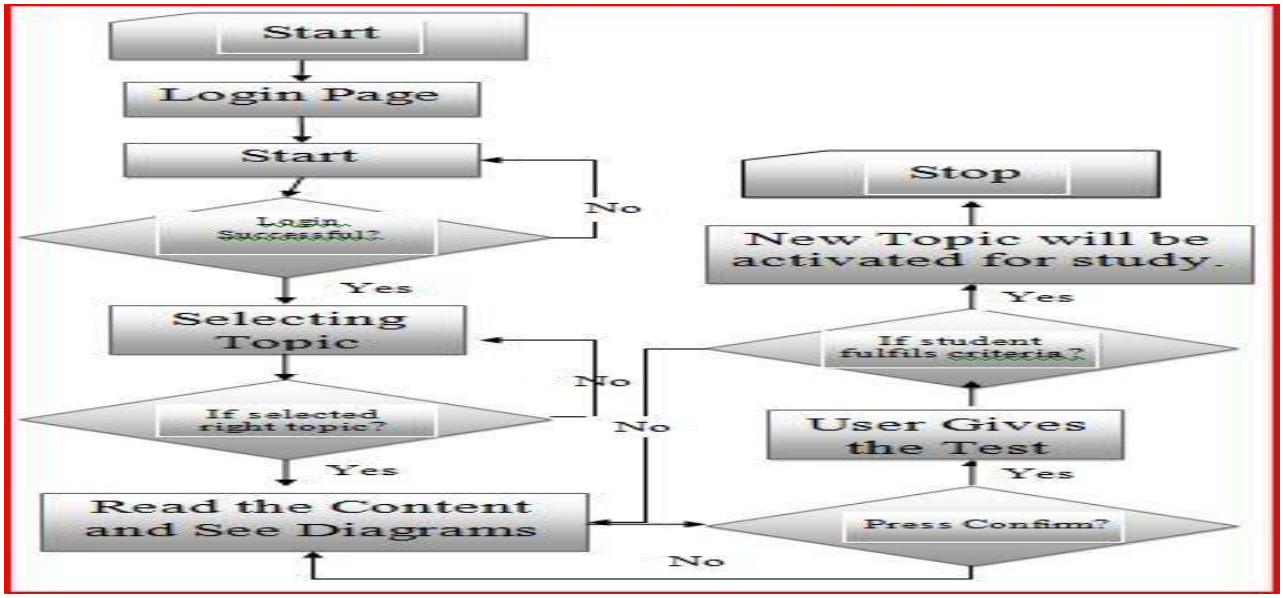


Figure 3 Flow Chart of Information flow in the system

4. CONCLUSIONS

This study has explored area of agent based intelligent tutoring system for the development of 'ProgTool' for teaching object-oriented programming concepts. In order to develop agent-based intelligent tutoring system, background research has been done. Various intelligent tutoring system have been studied to achieve this aim such as ELM-ART [9], a standalone and web version of tutoring system for teaching computer languages and system for teaching parameters passing in Java programming language.

Three layered architecture were chosen for developing agent based intelligent tutoring system. Knowledge Base Layer, Agent Layers and User Interface Layer are the three layers of the software architecture of the agent based intelligent tutoring system. Knowledge base layer consists of knowledge base of the 'ProgTool'. Agent Layers consists of three important agents because of system behaves as an intelligent human tutor. Pedagogical expert agent, feedback agent, and student agent are the agents of the system which interact with each other. Moreover, these also serves user interface layer and get the information from the database.

There are various advantages using agent-based intelligent tutoring. From the detail analysis of the 'ProgTool', it have been found that topic sequencing, visual representation, collaborative learning through student modelling, and exercises and tests are the distinguishing features of the 'ProgTool'. These features make it stand first from traditional ways of teaching such as books and electronic books. To conclude, 'ProgTool' is an excellent individualized method of teaching which can be used to increase the learning gains by students.

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