Abstract: Fuzzy logic has rapidly become one of the most successful of today’s technologies for developing sophisticated control systems. The reason for which is very simple. Fuzzy logic addresses such applications perfectly as it resembles human decision making with an ability to generate precise solutions from certain or approximate information. It fills an important gap in engineering design methods left vacant by purely mathematical approaches (e.g. linear control design), and purely logic-based approaches (e.g. expert systems) in system design. While other approaches require accurate equations to model real-world behaviours, fuzzy design can accommodate the ambiguities of real-world human language and logic. It provides both an intuitive method for describing systems in human terms and automates the conversion of those system specifications into effective models. Therefore there is a need for an adaptive online learning system that can let an instructor know how learners are progressing and thus the instructor can modify and disperse near real-time course content if learners are struggling with current content. Such systems provide an innovative method of instruction that adapts to the learner’s unique learning style. A model of a novel approach to collaborative adaptive learning is presented that utilizes learning modalities of instruction tailored to individual needs. At the heart of this approach is a fuzzy neural network (FNN) that evaluates comprehension makes instructional modality selections and collaborates with an instructor in tailoring course content.

Keywords: Adaptive online learning, Fuzzy logic, Intelligent tutoring systems, Fuzzy inference, Analytic hierarchy process

1. INTRODUCTION

Advances in Internet Technology have opened gateways to new types of Collaborative Systems and for specialized educational opportunities. There are different types of learners. Some may auditory learners, some may be visual learners and some may be kinesthetic learners. According to them Conventional Learning System was proposed. In the existing system, first the instructor takes the input from the user that i.e. the present condition of user (stress, alertness, lethal condition, age, etc...). According to the input given by the user, the instructor selects the modality (text, audio, and video) that suits the user and delivers the content in that modality. Instructor delivers all the modules (lessons) of the course in the same modality that the instructor selects in the beginning of the first module i the course. So he can’t change modality of the module in the middle if the user is not comfortable with the present one. This is limitation of this system.

Figure 1: Conventional Learning System

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In this system, we overcome the limitation of the Conventional learning system. In this system we are using the collaborative technology in conjunction with an adaptive training system utilizing fuzzy logic. In this system also instructor takes the present condition of the user (stress, alertness, etc...) and a preliminary short course is presented and also test is conduct. This user input and result of test is maintained in the user profile, the instructor selects the modality for the first module of the course using fuzzy logic and for end of the every
module a test is conducted. The results of the test and used modality are updated in profile and same process is repeated for every module till the end of the course. So, there is a feedback loop. Here there is an indirect interaction between the user and instructor known as collaborative technology. In addition to this there user has the flexibility to bypass the system choice and select the presentation modality.

Figure 2: Architecture of the individual system agent

Collaboration seems to have many definitions. To understand what collaboration is one must consider the differences in human interactions. There are three primary ways in which humans interact: conversational interaction, transactional interaction, and collaborative interaction: Conversational interaction is an exchange of information between one or many participants where the primary purpose of the interaction is discovery or relationship building. In this type of interaction there is a free exchange of information that has few if any constraints. Examples of this are email, text messaging and telephones. Transactional interaction involves the exchange of transaction objects where a major function of the transaction entity is to alter the relationship between individuals. The transaction defines a new relationship. For example purchasing a product for money is a transactional interaction. Such interactions usually have records and audit trails of some sort. In collaborative interactions the main function of the participant’s relationship is to alter a collaboration object. This is the opposite of a transactional interaction. The collaboration object typically is relatively dynamic and unstable. An example of this would could be and idea or in the case of this research the content and design of material to be presented in an adaptive learning system. Collaborative technology and adaptive learning is a new approach to training that has become an increasingly important solution to overcome the shortcomings of conventional learning systems. These systems take into consideration a learner’s preferences and material comprehension to customize the course presentation or modality.

The goal of our research is to design and develop a new collaborative model of an adaptive learning system that continuously learns about user’s abilities to comprehend and acquire knowledge. Such a model collaborates with the instructor to adjust course content and with learners to dynamically disperse modified content back to learners for future lessons. It does this by constant assessment of user’s comprehension and retention. Because this process is inherently ambiguous, a FNN is being developed to evaluate user’s ability. Thus, the system plays the roles of both the tutor as well as the learner.

2. AUTOMATIC ADAPTIVE ONLINE LEARNING SYSTEMS

Adaptive learning systems (ALS) address the fact that individuals learn differently by adapting the presentation of learning content to meet the varying needs and learning preferences of different learners. ALS uses technology that adapts to an individual’s learning style and modality and changes mode of presentation of instruction material. This enables faster learning by the user as the system tailors its instruction to user learning styles. Thus the system adapts to a user’s learning preferences and presents content objects accordingly. This can be a potential valuable contribution to learning technologies research.

Next-generation products depict the supportive learning role that technology can rightfully play in correcting learning problems that have continually perplexed training markets in the past. Adaptive learning is important because it enables learners to select their modular components to customize their learner-centric learning environments. Secondly, it enables them to offer flexible solutions that dynamically adapt content to fit individual real-time learning needs.

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The goal of learning systems research is to develop computer systems that provide or support effective learning experiences for a wide range of learners across a broad spectrum of subject areas. However most of the current, commercially available adaptive learning systems adopt a design wherein the system collects the preferences of the user and presents its coursework based such information.

Currently there are several adaptive learning systems that inventory the input provided by the learners, regarding their preferences for a specific learning style, environment and modality. They then provide a specific presentation model that best contribute to increasing the capacity of the individual to learn. These systems rely on user input and do not typically take into consideration that individuals are generally unaware what the best mode of learning for them is.

There are several different types of learning systems each of which has a specific style and purpose. For example a
hypermedia system emphasizes learning, reusability and adaptability in web-based education systems. Real Education is a company that plans to develop the technologies needed to enable nonprogrammers to design courses rapidly and provide materials and interactive instruction that are customized for each student.

Real Education develops a system known as the Real Adaptive Intelligent Learning System (RAILS), which being in its developmental stages, is a web-based tutoring system that allows educators to develop complex, interactive courseware that modifies itself during use to meet the individual needs of each learner.

Another effort, the National Institute of Standards and Technology (NIST) is developing a focused program on Adaptive Learning Systems, which aims at increasing the capacity and usability of instructional content production technology; improving the precision and context-sensitivity of search and retrieval technology; and improving quality of service levels of distributed, instructional systems which would help create a Web based learning environment that is scalable, manageable, and usable by a diverse end-user population.

VALA is a project under development at the University of Arizona. It focuses on developing architecture with a personalized user environment. VALA collects information from a user to develop a profile that is then used to decide the mode of presentation.

3. IMPLEMENTING FUZZY LOGIC

The architecture of the system we are developing is shown in Figure 4.2 This is an agent that conducts evaluation and content delivery modality change on a learner’s computer. The first stage in the operation of our system is to collect information from the user and build an initial user profile.

Factors we thought originally to be important in user learning and thus profile development are:

- age
- gender
- color preference
- educational attainment
- health {sick, not sick }
- stress level
- time of year
- hours a learner is most alert
- time of day currently

These factors were arbitrarily chosen as a starting point for research and are still in development and refinement. A part of our research will in the future be looking at how deletion of a factor may affect the effectiveness of our model. In the second stage, a preliminary short course is presented within which sections are presented in different modalities such as text, audio, video or mixed. In the third stage, the system evaluates the user performance. In the fourth stage, the user score is used to update the initial user profile, which is fed to the FNN as input data. The FNN analyzes this input and decides the presentation modality of the next module. Thus the module Mn is presented in the system chosen modality. This procedure continues till the end of the instruction material. At the end of each module, stage 3 and stage 4 are repeated. In addition, the user has the flexibility to bypass the system choice and select a different presentation modality. The user may revert or advance to any module or discontinue the presentation at any stage.

4. Design and Structure Of Fuzzy Logic

The learning ability of each individual can depend on several factors such as age, gender, time of the day, personal preferences, content of the material etc. In our system, an initial weight is assigned to each of these user profile factors. We make use of fuzzy logic to change these weights that contribute to the decision of choosing appropriate modality to present instruction material. A set of rules, known as membership functions, are developed to assign weights to each factor. The whole process can be subdivided into three stages:

- Fuzzification, rule evaluation or fuzzy inference
- Defuzzification

We make use of fuzzy set theory in the evaluation of user profile factors to determine the presentation modality. Fuzzy set theory is a generalization of classic set theory. In classic theory an element belongs or does not belong to a certain set. In fuzzy set theory an element can belong to a certain set partially and its affiliation can be represented by a real number within the range of [0, 1]. Therefore a membership function where $f(x)$ is a function giving an affiliation value within the range of [0, 1]. Sets with defined membership function are called fuzzy sets. Membership functions can have different characteristics and are mainly represented in a graphical form.

Fuzzy logic systems, which can reason with imprecise information, are good at explaining their decisions but they cannot automatically acquire the rules they use to make those decisions. These limitations have been a central driving force behind the decision of using Fuzzy system.
The Eval() function uses the Fuzzy module to decide the presentation modality. The crisp input is fed to the network and is converted to fuzzy input with the use of fuzzy membership functions. The membership functions can be linear or other membership functions such as Gaussian Membership functions etc. The calculations are then made on these fuzzy inputs with the fuzzy rules provided. Fuzzy rules are extracted from the rule base and are evaluated to result a set of rules optimum for the Defuzzification of the outputs. Centroid or Mean of Maximum Defuzzification methods can be used for defuzzifying the fuzzy outputs obtained. The crisp result thus obtained determines the presentation modality. The Eval() function includes all the three stages of training of the inputs, Fuzzification of the trained inputs and Defuzzification of the fuzzified outputs.

![Diagram of Eval() function]

**Figure 3: Eval()**

5. IMPLEMENTATION

The model presented in this paper is currently in the development and evaluation phase. Currently the system is being implemented in a networked laboratory running Linux RedHat and Windows XP. While the initial system will be operated on a single computer, we are architecting the system to be evaluated over a distributed environment, perhaps in conjunction with a commercial database system. Coding is currently being done using Java Server Pages and some unique data collection features found in Power Point. The current prototype is being evaluated for usability.

Some of the benefits of such a system could be:
- Better learning for individuals via tailoring of modality and content
- Collaborative feedback between instructor and individuals
- Broader view of overall effectiveness of the instructor
- Automated ability to teach a larger number and range of learners simultaneously

Our system aims at providing online content delivery and training by providing an environment that gives benefits of online as well as it provides class room environment...by means of student to instructor interaction as well as interaction among students.

![Diagram of implementation process]

In the paper we have gone for implementing online web based system in Java Server Pages. Our system has Registration process for creating an account for our web site. Each user is provided with a unique ID Registration process is free. One who registered to the site has the facility to interact with students through chat session. If any one is willing to take a course to study he must pay to register by means of demand draft to the specified address (presently).

In future we are going to make that money transfer through online. After registering course that student can access that particular course and go for classes when ever he wants with in the time span of that course. In our system for every lesson completion student must attend a test such that with result that he Get, our system can select the best modality for the student for next lesson by means of some fuzzy inputs. If student prefer to select the modality, he has that option too. By this way he has enormous exposure to lessons of that course at any time all over the duration of the course, as well we provide good platform for interaction among students as well instructors. After the end of course a date is fixed for students of that particular course to attend an online examination and certificates are issued to students...If student is not satisfied with what he did he can even go for registering for the same course and learn again.

6. CONCLUSIONS

Thus the collaborative model for course material delivery utilizing fuzzy logic can deliver the course delivery tailored to a learner learning modality and better potential retention of material by students. There is also an adaptive feedback to an instructor so that he can know the effectiveness of this material at instructing. This system also provides flexibility for the user to bypass the
instructor choice of modality and select different presentation modality.

Thus we overcome the limitations of the conventional learning system through collaborative and adaptive system using fuzzy logic.

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