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A SURVEY FOR ADAPTIVE EDUCATIONAL SYSTEMS USING ARTIFICIAL INTELLIGENCE

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Abstract- Traditional learning systems do not consider varying behaviors of learners and focus on evaluating people based on a fixed set of criteria. The drawback with this approach is that each candidate has a different pattern of learning and will grasp concepts differently. With the advent of Machine learning and Artificial Intelligence, it is easier to understand the candidates and evaluate things on the fly such as intellectual skills and expertise. Hence adaptive learning systems can be built which are tailor made for students. Artificial Intelligence techniques are useful in this aspect since they can simulate human reasoning and decision making and also minimize the uncertainty involved in learning. These techniques ensure that both learners and system evolve over time. The paper presents a survey of adaptive educational systems which use artificial intelligence techniques to effectively model student behavior.
Keywords – adaptive learning, machine learning, Bayesian networks, fuzzy logic, concept maps

1. INTRODUCTION

Learning technique in education varies for each student. Education must incorporate the behaviors of students. The approach of an adaptive system is to integrate the ability to monitor student's traits with the expertise needed. Hence it is necessary to design accurate models based on knowledge and personal traits. An expert tutor knows abilities of students, but is limited by the degree to which they can educate students. Smaller size of classes would imply more accuracy, which is not always the case. Electronic learning devises instructions to support learning digitally and can be synchronous or asynchronous. In synchronous learning, simultaneous delivery of instructions happens. In asynchronous learning, students can decide the time and pace of learning. Lack of communication is an issue in both scenarios.

Artificial Intelligence (AI) helps develop adaptive systems. Student abilities are monitored and adjusted to improve learning. The method of gathering and processing the behaviors of students is crucial. Course content can be modified through feedback. This helps students to achieve their goal of learning. Discovering student's traits is mandatory; therefore, accurate models must be created. The acquired data must be effectively exploited to benefit students. Hence AI is valuable as it can aid decision making. The AI techniques can handle uncertainty associated with behaviors.

The various techniques are Fuzzy Logic, Decision Trees, Bayesian Networks and Markov models. Intelligent systems can be developed for collaborative learning and content personalization. The paper also presents some methods in which machine learning can be used in adaptive educational systems.

The rest of the paper is organized as follows. Section II presents an overview of machine learning used for adaptive systems. Section III gives an idea about how Bayesian networks can be used for adaptive learning. Section IV depicts intelligent planning for learning. Section V gives an outline of usage of other artificial intelligence techniques used for adaptive learning. Section VI concludes the work.

2. MACHINE LEARNING FOR ADAPTIVE EDUCATIONAL SYSTEMS

Machine learning gives computers to learn data without being programmed explicitly. It consists of supervised and unsupervised learning. In supervised learning, algorithms use past data; while in unsupervised learning, the information to train is not classified or labeled.

In [1], a machine learning technique is introduced to predict student performance to handle differences in courses and the progress of students. A bi-layered structure with base predictors and ensemble predictors is created to make predictions. Course relevance is discovered using probabilities. The system keeps track of performance and takes into account how informative the course is. In base predictor, snap of current performance is used to generate local predictions. The local predictions and previous predictions together comprise the ensemble predictors. Based on course clustering, the predictors are trained. The model reduces complexity by taking into account only relevant courses. Decision trees, artificial neural networks and probabilistic algorithms are used for prediction. Exponentially Weighted Average Forecaster (EWAF) is used for ensemble

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learning. The latent factor model is used to cluster relevant courses. It solves sparse entries in courses. The technique gives valuable recommendations of courses. The issue is to include elective courses for predicting and recommending courses.
In [2], machine learning is used to construct a predictive model of GPA based on learning behaviors of students. The model develops strategies to intervene and help students who are at risk of failure. Predictors can be divided into academic, demographic and psychological categories. Grade point average (GPA) is a good measure of academic performance but it is limited by sample size and dimensionality. Hence self regulatory behaviors are used. A maximum weight first order dependence tree (MWDT) is constructed where each value depends on its parent. MWDT outperforms other classifiers and validates the selected features. To avoid bias in selection, cross validation is applied outside feature selection. A survey was conducted to find the behaviors of students. The conditional probabilities determine most accurate classifier among the features. The model overcomes drawbacks of traditional GPA Prediction and uses self-regulatory behaviors rather than previous performance. Cross validation improves accuracy by adding external variables. Students with poor performance are benefited. The scope for improvement is to include prior performance to improve accuracy of the model.
In [3], a research is done to predict student performance and improve quality of education. Machine learning tracks degradation in performance and reinforce student learning. Machine learning improves performance by experience and acquired knowledge. The information is observed and generalised to extract more rules. Induction is used to infer or conclude some information from some examples and it is classified into supervised and unsupervised learning. Supervised learning predicts based on existing scenarios while unsupervised learning is descriptive. Naïve Bayes, Support Vector Machines, tree based methods and rule based methods are used for prediction. The work ensures good data quality by analysing the acquired information. The accuracy however can be improved by using more supervised learning.

3. BAYESIAN NETWORKS FOR ADAPTIVE LEARNING SYSTEMS

Bayesian Network is a direct acyclic graph which disseminates and represents probabilities. The nodes and edges are interconnected to represent cause and effect relationship. The reliance of parent and node probabilities is given by conditional probability. The Bayesian network determines profile of students according to their behavior. Sometimes Bayesian network is ineffective if knowledge is too dynamic.
In [4], the Adaptive Educational System (AES) uses techniques which need cognitive state of students. Bayesian networks can monitor performance. The AES can cater to traits of students to increase learning, but this needs monitoring of knowledge. Artificial Intelligence techniques or probability theories are used to work on uncertain data. A knowledge assessment module is developed to facilitate reasoning. The Bayesian Network (BN) determines knowledge probabilities to make inferences. The vertices of the network are evidences of knowledge. The paper uses ontology for depiction of concepts and their reasoning. It sees even digital aspects of education and uses rules for consistent results. The hybrid model independently depicts students irrespective of their skill. The combination of BN and ontology makes use of rules for a dynamic setup. The paper diagnoses students facing issues and is sufficient for recommending useful information. The creation and support for BN need to be checked.
In [5], a dynamic Bayesian Network model (DBN) is obtained from conditional occurrences in machine learning. Computation is added to learning environments with narratives. Guidance is insufficient and hence personalizing learning can enhance outcomes. To automate agents, machine learning models are created from human demos. Classical planning and Markov processed are used for director tasks. A corpus collection is acquired for users and then models are learnt and evaluated. Time slices are used for DBN to find the state of the system and infer probabilities. The model has higher accuracy than naïve Bayes and similar methods. Participants have obtained better outcomes in this technique. But the drawback is that computational complexity is high for many users and prediction comes at the cost of runtime performance.

4. INTELLIGENT PLANNING FOR ADAPTIVE EDUCATIONAL SYSTEMS

Markov model is a collection of states which follow Markov property where the relation between true observation and any state is derived from probability distribution. It is a probabilistic function for a Markov chain. Model's state at a time is derived by state at an earlier time. States are described as a probability matrix with transitions between states.

4.1 Probability-Based Evaluation

In [6], intelligent tests are developed for education to guide the learning methodology. SIETTE, an adaptive testing system creates a hierarchy of concepts and then a question set. Accessibility, grading, timing, criteria to finalize tests and questions are important factors. The self-assessment mechanism gives hints and feedback to improve understanding. The computer adaptive testing theory uses valid and reliable diagnosis. Instead of heuristics, item response theory (IRT) uses knowledge level to test performance. Knowledge is considered as a numerical value and there is a relation between knowledge and response to questions. Probability distribution vectors are used for modelling students based on concepts. Adaptive tests alter difficulty of questions based on responses. Concept selection and question selection are necessary. Bayesian selection can be used for questions. The overall model calculates valid levels of knowledge and provides reliable evaluation. The model is updated to reflect understanding of students. The future scope is inclusion of more instructions to tune the adaptive testing.
In [7], self assessment of students is finished with Item Response Theory (IRT). The next inquiry is discovered utilizing System of Intelligent Evaluation Using Tests for Tele-education. Mentors can make tests and correct them. Input and clues

can be consolidated. Computerized adaptive tests (CATs) are converged with innovation. Understudies can effectively involve in learning. The information base is examined to give an inquiry and the student answers. The information level is assessed and additionally questions are posed. Latent qualities and conditional probabilities are utilized as a part of Item Response Theory. In SIETTE, diverse choices like true or false and various answers are conceivable. The information base is refreshed and result can be seen. The benefits are security and precise adjustment of tests. The performance can be self-dissected. The extension is that clues can be versatile and more powerful.

4.2 Content Personalization

In [8], intelligent planning helps improve content personalisation by adapting learning routes to give a recommendation system. Based on student profiles and course objectives, the routes are adapted and reused. If any failure occurs, the course can be modified to meet new goals. The description of interrelation of contents needs to be considered and the monitoring of learning routes has to be implemented. The routes must satisfy every student's profile.The main elements of e-learning are the background and student's preferences and learning routes of students. Knowledge is extracted to solve problems and find learning routes. The route is executed and adapted when needed. The model is consistent and applicable for varied size of profiles. It is useful for students; however some repositories are not of good quality. All information for planning is not provided under current standards. The drawback is that teachers may be reluctant to the changes.

In [9], a new adaptive educational web platform is developed which focuses on personalizing learning. The work helps tutors modify the manner in which topics are depicted. It also finds studying patterns for students. Technology has enhanced the ability to adapt instructions for student learning. Student involvement is also increased by gamification. Personalized learning creates motivated learners and improves grasping of material. It improves retention of knowledge and gives content according to student skills. The features are quick design of curriculum since assessment is done based on concept maps. The model guarantees success and equal focus on all students. It benefits students, tutors and colleges. The application uses Bootstrap, JQuery and SQL. The merits are integration of learning tools for students. The drawbacks are usage of internet and limited layout. Acceptance and modification to traditional system has to be considered.

4.3 Collaborative Learning

In [10], adaptive and intelligent systems are developed for support of collaborative learning to adapt to needs of the learner. Tutoring systems with intelligence apply AI during problem solving. Groups are formed for peer interaction and they use Bayesian networks. Association rules, fuzzy algorithms and clustering are applied to aid formation of groups. Rule based and Markov model based suggestions are given for dynamic feedback of activities to be done. This helps students manage time for learning. Collaborative learning systems can provide peer support and benefit learning by improving outcomes. The work is incoherent in assessing impact and needs assessment and interaction to be monitored. The drawback is that group formation has not been considered effectively.

5. OTHER ARTIFICIAL INTELLIGENCE TECHNIQUES

Concept maps are visual depictions of topics for retention of knowledge. They are preferred over traditional assessment since they find what the student knows about the subject.

5.1 Concept Map Approach

In [11], an artificial intelligence based tool is used to find student's comprehension of a topic using concept maps. The tool generates a curve which is analyzed and used to assess probabilities. The concept map checks if student has grasped concepts well and it analyses psychology of students. The concept maps developed by students are translated to XML, which is parsed and analyzed to determine concepts. The results are given to teachers for analysis. Each concept is unique but interrelation of concepts is not taken into consideration. The linking phrase id relates the concepts after verification. Three levels of concepts – 0, 1 and 2 are proposed based on direction of inheritance. Scoring of concepts is done randomly. The curve drawn for probability represents understanding and its slope verifies the information obtained. The implementation can be extended by Markov chains to extract more knowledge.

5.2 Fuzzy Logic Approach

Fuzzy logic extends the set theory as statements lying between truth and falsity. The fuzzy logic system has four stages: fuzzifier, rule base, inference engine and defuzzifier. Rules can be from experts or numerical data. Fuzzy rules represent learning behavior in a readable manner. They are transparent and can be easily assessed to explain the working of input and output.

In [12], adaptive systems are included in E-learning to create a personalised atmosphere for students. A fuzzy logic system is presented to deliver knowledge based on student traits for personalisation. A model is created and then adapted to learn preferences. Student's needs are divided based on knowledge, learning, etc. Feedback can help customise learning contents. For analysis of profiles accurately, the acquired data must be put to use in an effective way. To overcome issues of knowledge representation, the fuzzy model captures data and analyses input and output. The rules are extracted and then

knowledge is customised and delivered. The right content is presented and adapted based on the student. The model is flexible and can be expanded to change the rules. Another benefit is that many values can be accommodated for parameters. The issue is that higher numerical uncertainties cannot be handled in the model.

6. CONCLUSION

Concept maps are visual depictions of topics for retention of knowledge. They are preferred over traditional assessment since they find what the student knows about the subject. Adaptive educational systems take into account the varying needs of learners and diagnose specific needs of each student. They ensure that study materials are tailor-made for students. To establish accurate student models, it is essential to use the acquired data properly to create an adaptive environment. Artificial Intelligence techniques are helpful for adaptive systems as they imitate human problem solving and decision making. They handle uncertainties and promote effective learning. The paper presents a survey on machine learning, Bayesian Networks, Fuzzy Logic and intelligent techniques to personalize learning content and develop an effective adaptive educational system. The pros and cons of each technique are presented along with the future enhancements. The overall aim of the AI techniques is to ensure that both students and the learning system evolve with time.

7. REFERENCES

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