EVALUATION OF TRAINING EXECUTED BY WEB USING FUZZY RULE BASED EXPERT SYSTEMS

Ronei Marcos de Moraes [1] and Liliane dos Santos Machado [2]

Abstract *— This paper presents a methodology of evaluation of training executed by Web. It is an intelligent evaluation procedure that allows to classify a trainee learning using a fuzzy rule based expert system. The methodology proposed uses statistical measures, statistical models and appropriate statistical hypothesis testing to compare statistical measures and model parameters. Fuzzy measures, statistical measures and parameters and probability of significance from statistical testing of hypothesis are used as input for a fuzzy rule based expert system to construct a profile for trainee. Fuzzy rules are modeled by membership functions according to two specifications: sequence of tasks executed by experts and statistical measures from execution of correct procedures according to experts.*

Index Terms — Fuzzy expert systems, Intelligent training evaluation, Statistical methods, Web based education.

INTRODUCTION

There is a big problem in distance training or distance learning: the form of evaluation. Several discussions point out advantages and disadvantages of methodologies and suggestions about how to introduce evaluation components [7] in distance learning [8]. There are automatic and semi-automatic evaluation systems for analysis of students log files and creation of a profile for evaluation [28]. In this category we can find systems which trace student's actions over specific topics or utilized resources. Other systems [22] do the evaluation using tests, exercises, quizes and questionnaires. Brusilovsky and Miller [2] use local tests and a system with some intelligence to do not repeat tests applied before or to evaluate answers.

Unfortunately, these methodologies are incipient because they use short pre-defined evaluations. Even when the questions are presented randomly or use some intelligence, they are finite. Other limitation is that the student can not execute effectively the procedure for what he is been trained.

In this paper, we introduce a new approach by the use of an automatic evaluation system for training executed at distance. Several measures from user interaction in training executed by Web are used as input for a fuzzy rule based expert system [17]. Besides that, the expert system can be monitoring if specific important tasks are executed in the right sequence. With all these information, the expert system can construct a profile for trainee and emit relevant information about his performance in some pre-defined categories of training.

BACKGROUND

There are many examples of training systems by Web. Some of them are informative systems with several web pages with a lot of information about a specific subject as, for example, the website *Electronic Music Interactive* at University of Oregon [27]. In several cases, informative systems do not present any form of evaluation. Their function is simply to transmit knowledge using massive multimedia resources [18]. Others are realistic-based training using high-resolution graphics and permit direct interaction simulating pseudo-real actions over mechanisms [23]. Some of those systems have an evaluation system close to the training system. The evaluation system collects relevant variables during user interaction by Web.

Some methodologies have been proposed for evaluation in simulated training. McBeth et al. [15] proposed a methodology to evaluate medical procedures using basic statistics. Pucel and Anderson [23] developed a computational ophthalmic simulation to test a person's ability to perform psychomotor tasks using basic statistics too. Recently, Machado and Moraes [10]-[12] Machado, Moraes e Zuffo [13] e Moraes e Machado [19]-[21] proposed advanced statistical techniques or tools based on fuzzy logic to evaluate training based on virtual reality simulators [3]. Those systems are capable to collect specific data from training execution and to compare them to models (statistical or logic) pre-defined that are called classes of performance. For example, five models can correspond to five classes of performance in training: *you need much more training*, *you need more training*, *you need training*, *your training is good* or *your training is excellent* [13].

In several of those works, it is showed that with modifications some techniques can be generalized for applications in training executed at distance. For that cases, we propose a new evaluation technique using a fuzzy expert system. A fuzzy rule based expert system uses fuzzy measures and statistical information from training variables

[1] Ronei Marcos de Moraes, Department of Statistics, Federal University of Paraíba, Cidade Universitária s/n CEP 58.051-900 João Pessoa – PB - Brazil, ronei@de.ufpb.br

[2] Liliane dos Santos Machado, Department of Informatics, Federal University of Paraíba, Cidade Universitária s/n CEP 58.051-900 João Pessoa – PB - Brazil, liliane@di.ufpb.br

as input to construct a profile for trainee. This expert system can classify the trainee into classes of training.

THEORETICAL ASPECTS

In this paper we use a set of theoretical aspects: statistical measures and models, fuzzy sets and expert systems. The first one is a set of statistical measures commonly used for general purposes as mean, median, mode, standard deviation, etc [25]. Besides, we also use statistical models based on regression analysis to modeling linear [4] and non-linear [24] sequences of performance in task execution. In some cases is interesting to use statistical time series analysis to perform better statistical models using time as a variable [1]. Statistical measures and statistical parameters of models can be compared using appropriate statistical testing of hypothesis: nonparametric [9] or parametric [16]. As results of these comparisons, we have statistical decisions about equality or difference between parameters and a measure of probability of significance.

As it is possible that some variables in virtual world do not present an exactly correspondence to the real world, some measures can not be exact. Then we must use fuzzy sets to measure those variables [6]. These fuzzy variables are measures based on membership functions previously defined by experts.

A fuzzy rule based expert system combines logically all information about fuzzy and non-fuzzy variables to making decisions about complex conjectures [26]. Fuzzy expert system uses logical rules as:

IF *A* AND *B* OR *C* THEN *D*

where *A*, *B*, *C* and *D* are fuzzy sets. It is important to note that a crisp set can be interpreted as a fuzzy set with a particular membership function [29].

The connectives AND and OR are implemented by a t-norm and a t-conorm, respectively [5]. The implication operator THEN is implemented by t-norm *min*. This particular configuration of operator characterize a fuzzy inference engine called Mandani type [14].

EVALUATION SYSTEM

From a realistic-based training by web, we can collect several information about user interaction. Sequence of executions, measures, etc., can be relevant information for an evaluation system. In web-server all interactions can be recorded in specific log-files. From these files, statistical and fuzzy information can be obtained.

In this paper, we propose a new conception for an evaluation system of training executed by web using fuzzy rule based expert system. This system uses statistical measures, statistical parameters, statistical decisions, probabilities of significance and fuzzy measures as input for a fuzzy expert system.

All information (statistical measures, statistical parameters, statistical decisions, probabilities of significance and fuzzy measures) is used as input for a fuzzy rule based expert system. Experts predefine the rules of this fuzzy expert system with objective of creating a user profile. Fuzzy rules are modeled by membership functions according to following specifications, according to experts:

- Sequence of tasks executed;
- Statistical measures from execution of correct procedures;
- Statistical models from execution of training by experts and trainees;
- Statistical decisions from statistical testing of hypothesis and probability of significance, respectively.

Experts supply their knowledge for the construction of the expert system. However, some numerical characteristics and comparative forms are very difficult to be translated in rules. So, statistical information can be acquired from previous execution of procedure by experts. These statistical measures and parameters are introduced in the expert system as complementary information to refine knowledge. Statistical models from expert executions are used as models of comparison with models generated by trainee. Statistical testing of hypothesis is used to calculate probability of difference between trainee's model and experts' model. That information serves as support for the final decision of the user's training classification.

It is interesting to note that the combination of statistical models and testing of hypothesis can be considered a pre-classification or a pre-evaluation. From this consideration, the evaluation system proposed in this paper is similar to two-stage evaluator, as proposed in [10]. In fact, it is not a pure two-stage evaluator, since part of the information is not used by the first stage.

This way, the expert system presented must construct a profile for trainee using information collected from his training and it can classify the trainee into classes of training. In this work, we use five classes of training, according to [13]:

- *your training is excellent* – trainee is qualified to execute a real procedure .
- *your training is good* – trainee is almost qualified to execute a real procedure. Performance is good, but it can be better.
- *you need training* – trainee needs training to be qualified. Performance is regular.
- *you need more training* – trainee needs more training to be qualified. Performance is bad.
- *you need much more training – trainee is a beginner. Performance is very poor.*

Figure 1 shows the blocks diagram of the evaluation system. User executes a realistic-based training by web interacting with the system. The interactions are monitored by modules, which can make measures, modeling and testing of hypothesis. A fuzzy rule based expert system

receives that information and it can classify the training in predefined classes of performance. The final classification is returned to the user.

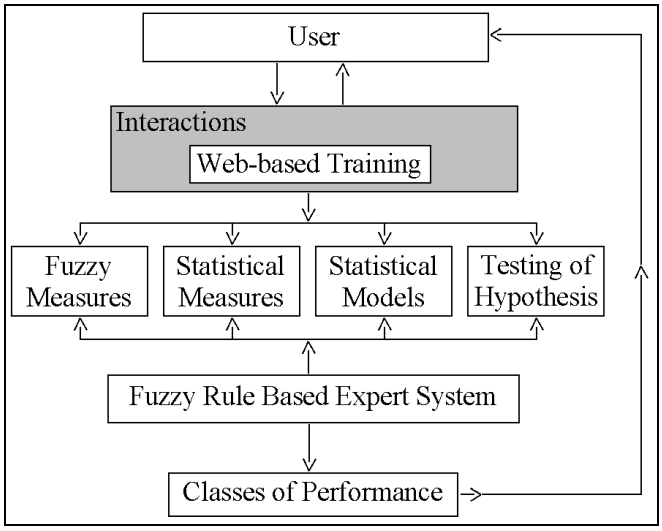

FIGURE. 1
DIAGRAM OF THE NEW EVALUATION SYSTEM PROPOSED FOR TRAINING EXECUTED BY WEB.

CONCLUSIONS

In this paper, we introduced a new approach of evaluation for training executed at distance by use of an automatic evaluation system. This methodology uses measures, models and statistical decision making from user interaction data collected over training executed by Web as input for a fuzzy rule based expert system. From this information, the expert system can classify a trainee into pre-defined categories of training.

However, this approach can not be used in any kind of training system by Web. To apply correctly this methodology it must be used over a realistic-based training. In this kind of training system, it is possible to collect information about user interaction.

REFERENCES

[1] Box, G. E. P.; Jenkins, G. M.; Reinsel, G.; Time Series Analysis: Forecasting and Control. Englewood Cliffs: Prentice Hall, 3rd Ed., 1994.

[2] Brusilovsky, P.; Miller, P., Web-based testing for distance education. In: P. De Bra and J. Leggett (eds.) Proc. WebNet, World Conference of the WWW and Internet, Honolulu, USA, 149-154, 1999.

[3] Burdea, G.; Coiffet, P.; Virtual Reality Technology. 2nd ed. New Jersey, John Wiley & Sons, 2003.

[4] Draper, N. R.; Smith, H.; Applied Regression Analysis. Wiley-Interscience, 3rd Ed., 1998.

[5] Driankov, D.; Hellendorn, H.; Reinfrank, M.; An Introduction to Fuzzy Control. New York: Springer Verlag, 1993.

[6] Dubois, D.; Prade, H. Fuzzy sets and systems - theory and applications. New York: Academic Press, 1980.

[7] Hopper, M., Assessment in WWW-Based Learning Systems: Opportunities and Challenges. J.UCS: Journal of Universal Computer Science, v.4, n. 4, p. 330-349, 1998.

[8] Keegan, D., Foundations of Distance Education. 2nd Ed. London, Routledge, 1991.

[9] Lehman, E. L.; D ' Abrera, H. J. M.; Nonparametrics - Statistical Methods Based on Ranks. San Franciso, Holden-Day, 1975.

[10] Machado, L. S.; Moraes, R. M.,. An Online Evaluation Of Training in Virtual Reality Simulators Using Fuzzy Gaussian Mixture Models and Fuzzy Relaxation Labeling. Proc. 2003 IASTED International Conference on Computers and Advanced Technology in Education (CATE'2003). Rhodos, Greece p. 192-196, 2003.

[11] Machado, L. S.; Moraes, R. M., Neural Networks for Online Training Evaluation in Virtual Reality Simulators. Proc. World Congress on Engineering and Technology Education - WCETE'2004. March, Santos, Brazil, p. 157-160, 2004.

[12] Machado, L. S.; Moraes, R. M., Online Training Evaluation in Virtual Reality Simulators Using Evolving Fuzzy Neural Networks, Proc. 6th International FLINS Conference. September, Blankenberge, Belgium, 2004. To appear.

[13] Machado, L. S.; Moraes, R. M. and Zuffo, M. K., A Fuzzy Rule-Based Evaluation for a Haptic and Stereo Simulator for Bone Marrow Harvest for Transplant. Proc. Phantom Users Group – 2000. Setembro, Aspen, USA, 2000.

[14] Mamdani, E. H.; Assilian, S.; An Experiment in Linguistic Synthesis with a FuzzyLogic Controller, International Journal of Man-Machine Studies, vol.7, pp. 1-13, 1975.

[15] McBeth, P. B. et al., Quantitative Methodology of Evaluating Surgeon Performance in Laparoscopic Surgery. Studies in Health Technology and Informatics: Medicine Meets Virtual Real.ity, v. 85, pp.280-286, 2002.

[16] Mood, A. M.; Grabyll, F. A.; Boes, D. C.; Introduction to the Theory of Statistics. Tokyo. McGraw Hill, 1974, 3rd. ed.

[17] Moraes, R. M.; An Architecture of Fuzzy Expert Systems fo Image Classification Using Operators of Mathematical Morphology. PhD Thesis. Instituto Nacional de Pesquisas Espaciais, São José dos Campos, Brazil, 1998 [in Portuguese].

[18] Moraes, R. M. e Machado, L. S., Network Based Education to Statistics Education. Proc. International Conference on Information Technology Based Higher Education and Training (ITHET'2001) [cdrom]. July, Kumamoto, Japan, 2001.

[19] Moraes, R. M.; Machado, L. S., Hidden Markov Models for Learning Evaluation in Virtual Reality Simulators. International Journal of Computers & Applications, v.25, n.3, pp. 212-215, 2003.

[20] Moraes, R. M.; Machado, L. S., Using Fuzzy Hidden Markov Models for Online Training Evaluation and Classification in Virtual Reality Simulators. International Journal of General Systems. v. 33 n.2-3, pp. 281-288, 2004.

[21] Moraes, R. M.; Machado, L. S., Continuous Evaluation in Training Systems Based on Virtual Reality. Proc. Global Congress on Engineering and Technology Education (GCETE'2005). March, Bertioga, Brazil, 2005. To appear.

[22] Pesin, L.; Specht, M.; Kravik, M., Assessment Support In Web-Based Authoring And Learning Environment. Proc. 2003 IASTED International Conference on Computers and Advanced Technology in Education (CATE'2003). Rhodos, Greece, p 186-191, 2003.

[23] Pucel, D. J.; Anderson, L. D., Developing Computer Simulation Performance Tests: Challenges and Criteria. Proc. 2003 IASTED International Conference on Computers and Advanced Technology in Education (CATE'2003). Rhodos, Greece, p 170-174, 2003.

[24] Seber, G. A. F.; Wild, C. J.; Nonlinear Regression. New York: Wiley, 1989.

[25] Tukey, J. W.; Exploratory Dates Analysis. New York. McGraw Hill, 1977.

[26] Turban, E.; Aronson, J. E.; Decision Support Systems and Intelligent Systems. New Jersey, Prentice Hall, 5th ed., 1998

[27] University of Oregon. Electronic Music Interactive. [online] http://nmc.uoregon.edu/emi/emi.php.

[28] Zaina, L. A. M. et al., Comparative Analysis of Manager Tools to Distance Learning. International Conference on Engineering and Technology Education (INTERTECH'2002). March, Santos, Brazil [cdrom], 2002 [in Portuguese].

[29] Zadeh, L.A.; Fuzzy Logic, Computer, vol..1, pp. 83-93, 1988.