CONTINUOUS EVALUATION IN TRAINING SYSTEMS BASED ON WEB

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

Abstract *— The approach of continuous evaluation is an important tool in the learning process. However, in training based on Web it is not applied. This paper presents a methodology of evaluation that uses the continuous evaluation approach to provide a user profile. That profile is a database, which contains information about several training from each user. The database is constructed using statistical measures of describing center and spread of distributions, tables and statistical graphics (time depended or not). The union of classical statistics information used as input to a fuzzy rule based expert system gives the methodology proposed. This new approach is a diagnostic tool that enables a trainee to understand the areas in which he presents difficulties.*

Index Terms — Continuous Evaluation, Evaluation Training, Fuzzy Rule Based Expert Systems, Statistical Tools, Training by Web.

INTRODUCTION

The researches in training evaluation based on Web [17] are recent. Several discussions point out advantages and disadvantages of methodologies and suggestions about how to introduce evaluation components [10] in distance learning [11]. 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 [19] do the evaluation using tests, exercises, quizes and questionnaires. Brusilovsky and Miller [4] use local tests and a system with some intelligence to do not repeat tests applied before or to evaluate answers.

However, those methodologies did not use any technique of continuous evaluation to improve trainee performance. Continuous evaluation is a good tool used in present and distance learning to help the construction of knowledge and cognitive training [1][9]. In our case, the goal is to construct a diagnostic to help users to understand their difficulties and solve them.

This work proposes a new conception of continuous evaluation to construct a trainee profile from his several trainings and to help him to improve his performance [2][5]. This conception is composed by the union of statistical tools, for measure observed variables during training, and a fuzzy rule based expert system, to construct the trainee profile.

THEORETICAL ASPECTS

A tool for continuous evaluation must be interconnected with an on-line evaluation system and must receive from it information about all variables of interest. An evaluation system works near a simulator of training and should be capable to monitor user interactions while he operates the simulation system. For that, it is necessary to collect the information about all user interactions with the system. This information will be used to feed the evaluation system. In the Figure 1, we can observe that a training simulator and a system of evaluation are independent systems, however they act simultaneously. Several methodologies were proposed for evaluation systems in training and that can be used in this context [14][15][19][20].

The user interactions with the system are monitored and the information is sent to the evaluator system that analyzes the data. It emits an evaluation report about the user performance at the end of the training according pre-defined classes of performance. Each class of the possible performance classes is defined from expert's knowledge.

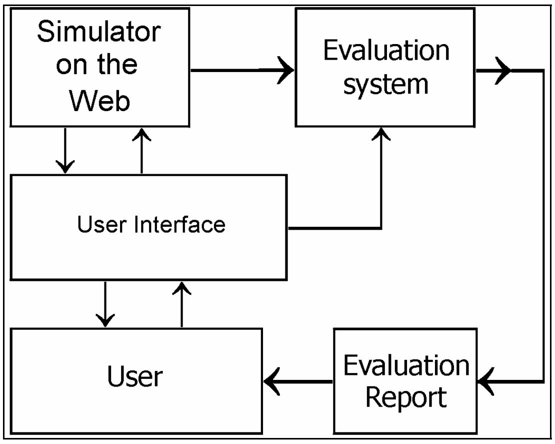

FIGURE 1.
DIAGRAM OF A SIMULATOR ON THE WEB WITH AN EVALUATION SYSTEM.

The interaction variables will be monitored according to their relevance to the training. This way, each application

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will have its own set of relevant variables that will be monitored [18].

Recently, a computational system for continuous evaluation training was proposed for training based on virtual reality [18]. That methodology for continuous evaluation uses data collected from user interaction in his several training to create a user profile. From data collected a database is created with specific and relevant variables. New information is stored from each training executed. From this information, an expert system can create a user profile and a continuous evaluation report. The continuous evaluation report presents the trainee profile and shows the execution performance of specific tasks.

For the reader's better understanding, we present first a short review about statistical methods, fuzzy sets and fuzzy rule based expert system.

Statistical Methods

In this paper we use a set of theories: statistical methods, fuzzy sets and fuzzy expert system. The first one is divided as:

- statistical measures;
- statistical tables;
- statistical graphics;
- statistical models (time dependent or not);
- statistical testing of hypotheses and
- statistical decision making.

A set of statistical measures commonly used for general purposes as mean, median, mode, standard deviation, etc [24] can be used to describe user interactions during the training. Statistical tables and graphics could be used to transmit specific information to the user to better understanding of results of his training.

Besides, statistical models based on regression analysis can be used to construct linear [6] and non-linear [22] model for sequences of steps in task execution. In some cases can be interesting to use statistical time series analysis to perform better statistical models using time as a variable [3]. Statistical measures and statistical parameters of models can be compared using appropriate statistical testing of hypothesis: nonparametric [12] or parametric [16].

As results of these comparisons, we can have statistical decisions about equality or difference between parameters and a measure of probability of significance. The information synthesized by statistical measures and parameters helps to construct a profile for user and his evaluation report.

Fuzzy Sets

As it is possible that some variables in the training system do not present an exactly correspondence to the real world, some measures cannot be exact. Then we must use fuzzy sets to measure those variables [7].

In classical set theory a set A of a universe X can be expressed by means of a membership function $\mu_A(x)$, with μ_A: $X \rightarrow \{0,1\}$, where for a given $a \in A$, $\mu_A(a)=1$ and $\mu_A(a)=0$ respectively express the presence and absence of a in A. Mathematically:

$$\mu_A(x) = \begin{cases} 1, & \text{if } x \in A \\ 0, & \text{if } x \notin A \end{cases} \qquad (1)$$

Lofti Zadeh [26] introduced the fuzzy set theory in 1965. A fuzzy set or fuzzy subset is used to model an ill-known quantity. A fuzzy set A on X is characterized by its membership function μ_A: $X \rightarrow [0,1]$. We say that a fuzzy set A of X is "precise" when $\exists\ c^* \in X$ such that $\mu_A(c^*)=1$ and $\forall c \neq c^*$, $\mu_A(c)=0$. A fuzzy set A will be said to be "crisp", when $\forall c \in X$, $\mu_A(c) \in \{0,1\}$.

The intersection and union of two fuzzy sets are performed trough the use of *t-norm* and *t-conorm* operators respectively, which are commutative, associative and monotonic mappings from $[0,1] \rightarrow [0,1]$. Moreover, a t-norm Γ (respec. t-conorm $\perp$) has 1 (respec. 0) as neutral element (e. g.: $\Gamma=min$, $\perp=max$) [8]. Thus, we can define intersection and union of two fuzzy sets as:

The intersection of two fuzzy sets A and B, with membership functions $\mu_A(x)$ e $\mu_B(x)$ is a fuzzy set C with membership function given by:

$$C=A \cap B \Leftrightarrow \mu_C(x)= \Gamma\{\mu_A(x),\mu_B(x)\},\ \forall x \in X. \qquad (2)$$

The union of two fuzzy sets A and B, with membership functions $\mu_A(x)$ e $\mu_B(x)$ is a fuzzy set C with membership function given by:

$$C=A \cup B \Leftrightarrow \mu_C(x)= \perp\{\mu_A(x),\mu_B(x)\},\ \forall x \in X. \qquad (3)$$

The complement of a fuzzy set A in X, denoted by $\neg A$ is defined by:

$$\mu_{\neg A}(x) = n(\mu_A(x)),\ \forall x \in X. \qquad (4)$$

where: n: $[0,1] \rightarrow [0,1]$ is a negation operator which satisfies the following properties:

- $n(0)=1$ and $n(1)=0$
- $n(a) \leq n(b)$ if $a>b$
- $n(n(a))=a,\ \forall\ x \in [0,1]$

and a negation is a strict negation if it is continuous and satisfies

- $n(a)<n(b)$ if $a>b$.

The main negation operator which satisfies these four conditions is $n(a) = 1-a$.

The implication function between two fuzzy sets *A* and *B*, with membership functions $\mu_A(x)$ e $\mu_B(x)$ is a fuzzy set *C* with membership function given by:

$$C{=}A \Rightarrow B \Leftrightarrow \mu_C(x,y)= \nabla\{\mu_A(x),\mu_B(y)\},\ \forall x\in X,\ \forall y\in Y \quad (5)$$

where $\nabla: [0,1]^2 \rightarrow [0,1]$ is an implication operator which obeys the following properties: $\forall a, a', b, b' \in [0,1]$:

- If $b \leq b'$ then $\nabla(a,b) \leq \nabla(a,b')$;
- $\nabla(0,b)=1$;
- $\nabla(1,b)=b$.

The pure implications obeys too:

- If $a \leq a'$ then $\nabla(a,b) \geq \nabla(a',b)$;
- $\nabla(a, \nabla(b,c))= \nabla(b, \nabla(a,c))$.

Fuzzy Rule Based Expert System

Expert systems [21] use the knowledge of an expert in a given specific domain to answer non-trivial questions about that domain. For example, an expert system for image classification would use knowledge about the characteristics of the classes present in a given region to classify a pixel in an image of that region. This knowledge also includes the “how to do” methods used by the human expert. Usually, the knowledge in an expert system is represented by rules of the form:

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IF <condition> THEN <conclusion>.
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Most rule-based expert systems allow the use of connectives AND or OR in the premise of a rule, and of connective AND in the conclusion. From rules and facts, new facts will be obtained through an inference process.

In several cases, we do not have precise information about conditions or conclusions, then the knowledge in the rules cannot be expressed in a precise manner. Thus, it can be interesting to use a fuzzy rule-based expert system [27].

An example of simple fuzzy rule could be:

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IF <access to the help is persistent>
    THEN <user is Novice>.
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where “persistent” can be characterized by a fuzzy set.

METHODOLOGY

The methodology proposed for continuous evaluation uses data collected from user interactions with training system by Web, in his several training to create a user profile, as proposed by Moraes and Machado [18]. That information is used to evaluate trainee and improve his performance in real tasks [23]. From data collected from training, a database is created with specific and relevant variables. New information is stored from each training executed.

Statistical tools are programmed to make an automatic analysis of the database using statistical measures, as mean, median, mode, standard deviation, etc. Besides, statistical models based on regression analysis to perform linear and non-linear modeling or even statistical time series analysis can be used to perform better statistical models for relevant aspects of training. Statistical measures and statistical parameters of models can be compared using appropriate statistical testing of hypothesis, according to statistical distribution of data. 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 can be measured in an approximate way, then we must use fuzzy sets to perform models for them [13]. Experts previously define these fuzzy membership functions for those variables. A fuzzy rule based expert system combines logically all information about fuzzy and non-fuzzy (statistical) variables to making decisions about complex conjectures [25].

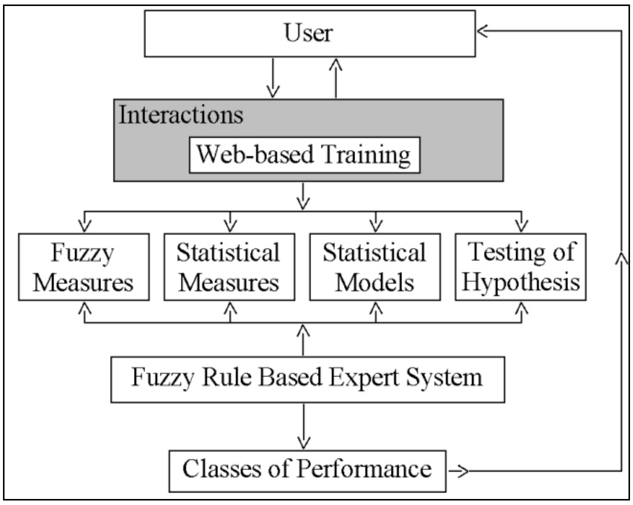

FIGURE. 2
DIAGRAM OF AN EVALUATION SYSTEM PROPOSED FOR TRAINING EXECUTED BY WEB [18].

Figure 2 shows the blocks diagram of a evaluation system for training performed by Web [18]. User executes a realistic training based on 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. In this paper, we use five classes of training, according to [13]:

- *your training is excellent – trainee is qualified to execute a real procedure* .Procedure is well executed.

- *your training is good – trainee is almost qualified to execute a real procedure.* Performance is good, but it could 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.

From the information about users performance and others details, as statistical information and models, the fuzzy expert system constructs an individual profile for trainee and a continuous evaluation report. The continuous evaluation report presents the trainee profile and shows, with statistical measures, tables, graphics and models, execution performance of specific tasks. Figure 3 shows the new methodology presented.

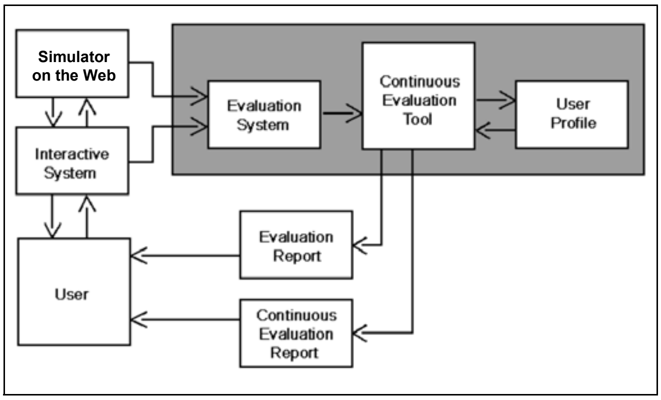

FIGURE 3.
DIAGRAM OF THE NEW EVALUATION SYSTEM WITH APPROACH OF CONTINUOUS EVALUATION.

In Figure 3, it can be observed that the Evaluation System from Figure 1 has more components now. The Continuous Evaluation Tool and the User Profile were incorporated (gray area in Figure 3). The new evaluation system creates two kinds of report: evaluation report and continuous evaluation report. The first report is about the user performance on the last training. The continuous evaluation report is about all set of training.

The first time a user executes the training, the Evaluation Report emits information about the user performance at the end of the training according to classes of performance previously defined. The Continuous Evaluation Report presents information about user performance above specific tasks using statistical measures, tables, graphics and models. Both reports present information from the present training. But, additionally, the Continuous Evaluation Report will show accumulative information about sequence of training for that user.

APPLICATION

This methodology can be applied for any activity of training, especially those where Internet is the way to access it. In this context, continuous evaluation is an interesting tool to improve constructing of knowledge. This tool is capable to show to the user his qualities and his deficiencies in execution of procedures.

In the methodology proposed here, experts predefine the rules of a fuzzy expert system to create 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, experts can acquire statistical information from previous execution of procedure. These statistical measures and parameters are introduced in the expert system as complementary information to refine the knowledge. Statistical models from expert executions are used as models of comparison with models generated by trainee. A statistical testing of hypothesis is used to calculate probability of difference between the trainee's model and the experts' model. That information serves as support for the final decision of the user's training classification.

The user's performance is shown in reports of the evaluation system through statistical tables, statistical graphs and statistical tests for better understanding of the results. These reports created by the system can guide the user to improve his performance in specific aspects of his training.

The methodology proposed in this paper is being used in the construction of a training system in statistical analyses for the graduation students in Statistics of UFPB. In that training system for the Web, the student should choose the correct statistical analyses for several simulate practical situations in his future profession.

CONCLUSIONS

In this paper we introduce a new methodology for evaluation training in the Web using the continuous evaluation approach. This methodology can emit to user information about his performance at the end of the training according to classes of performance previously defined, as proposed in others methodologies. Moreover, this methodology can provide information to user about his performance in specific tasks in the training.

A system is under development using the proposed methodology for a statistical diagnostic tool, which helps a student to understand practical situations of his future profession. From information presented by the evaluator system, the user can solve his difficulties and improve his performance.

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