Proceedings of the 2013 Federated Conference on
Computer Science and Information Systems pp. 111–114

Prediction of School Dropout Risk Group Using Neural Network

Valquíria R. C. Martinho
Department of Electro-Electronic
Federal Institute of Mato Grosso
Rua Zulmira Canavarros, nº. 95
CEP: 78000-000
Cuiabá, MT, Brazil
vribeiro@terra.com.br

Clodoaldo Nunes
Department of Informatics
Federal Institute of Mato Grosso
Rua Zulmira Canavarros, nº. 95
CEP: 78000-000
Cuiabá, MT, Brazil
cncefet@gmail.com

Carlos Roberto Minussi
Laboratory of Intelligent Systems
Electrical Engineering
Department, Campus of Ilha
Solteira, UNESP Av. Brasil 56,
PO Box 31 CEP: 15385-000
Ilha Solteira, SP, Brazil
minussi@dee.feis.unesp.br

***Abstract*—Dropping out of school is one of the most complex and crucial problems in education, causing social, economic, political, academic and financial losses. In order to contribute to solve the situation, this paper presents the potentials of an intelligent, robust and innovative system, developed for the prediction of risk groups of student dropout, using a Fuzzy-ARTMAP Neural Network, one of the techniques of artificial intelligence, with possibility of continued learning. This study was conducted under the Federal Institute of Education, Science and Technology of Mato Grosso, with students of the Colleges of Technology in Automation and Industrial Control, Control Works, Internet Systems, Computer Networks and Executive Secretary. The results showed that the proposed system is satisfactory, with global accuracy superior to 76% and significant degree of reliability, making possible the early identification, even in the first term of the course, the group of students likely to drop out.**

I. Introduction

HISTORICALLY, school dropout is one of the most complex and crucial problems in education, causing social, economic, political, academic and financial damage to all the people involved in the educational process, from the students to the governmental and promotional agences that long for efficient strategies to reduce the indexes of school dropout, since the measures adopted up to now did not have the desired effect.

In relation to higher education, school dropout is an international problem. Although its indexes show considerable variations among different nations, they show that in fact school dropout is present and strikes more and more a higher number of higher educational institutes (HEI) worldwide.

It is worth mentioning the United States - USA, with a dropout rate in colleges and universities of around 40%, representing a decline in the index of students graduated in higher education. Conversely, China and India empower higher education, increasing the conclusion index. Between these extremes lies Brazil, presenting a mean dropout index of about 20%.

Even taking into account all the differences and specificities of the (HEI) of different nations, the difficult task of solving the evasion problem is still common ground between them.

From this perspective, prevention and intervention programs are developed and structured taking into account the results of researches that identify the possible causes that generate the phenomenon of evasion. However, such measures could be more fruitful if there was prior knowledge of the students prone to evasion. And, for this, the development of methods, instruments or systems capable of previously making this identification is necessary.

To meet this need an intelligent, ambitious and innovative system was developed, for the prediction of risk groups of student dropout in presential higher education courses [1], using artificial intelligence techniques, the Fuzzy ARTMAP Neural Network [2-4]. This network has a structure in which the training is carried out in a supervised and self-organized way, with the possibility of continued learning [2].

This paper aims at presenting and making the developed intelligent system available as a possibility of identifying, in a proactive, continued and accurately the students of the traditional presential education, prone to evasion in higher education. And also to disseminate their fruitful results that contributed to the development of prevention and intervention programs, in order to improve retention of those students identified in the institution [1].

II. ART and FUZZY ARTMAP Neural Networks

The Artificial Neural Networks (ANN) [5] are computational tools that emulate the human brain and learn with the experience, trying to model and simulate its learning process, organizing its neurons in such a way that they will be capable of processing the information.

The ART network systems are able to solve the "stability-plasticity" dilemma. They are plastic because they are able to learn to adapt to a changing environment and, at the same time, preserve their previously learned knowledge while maintaining their ability to learn new patterns, therefore they are stable.

The basic structure of an ART neural network consists of two subsystems of attention and orientation, where some elements such as: two layers of neurons (F1 and F2) and their synaptic weights (Wij amd Vji), the module parameter vigilance (ρ) and the module reset are arranged and inter-linked.

Briefly, the process of classification of an ART network consists of four phases [6]:

978-1-4673-4471-5/$25.00

- Recognition: recognizes the stimuli produced in layer F2 and selects the category of higher value after calculating the function choice.

- Comparison: through the vigilance parameter, tests the similarity between the input vector and the prototype vector, whether allowing or not the inclusion of the pattern input in the category. If the vigilance parameter is not met, the input vector is stored in another neuron.

- Search: for every new input vector, searches for a neuron in layer F2 to represent it.

- Training: the training only starts after the conclusion of the search process, it can occur quickly or slowly.

The Fuzzy ART neural network [7] uses the theory of the fuzzy sets, employing the minimum operator (^) AND Fuzzy, enabling the treatment of patterns of binary and analogical input, in an interval [0, 1], and increasing the generalization ability of the network.

In the Fuzzy ARTMAP model, two ART modules are interlinked through an inter-ART module, called Field Map. This module has a self-regulatory mechanism called match tracking that seeks for "marriages" or combinations among the categories of ARTa and ARTb modules, aiming to increase the generalization level and reduce the network error [2].

The architecture of the Fuzzy-ARTMAP neural network, has been designed to conduct supervised learning in an environment or set of multidimensional data. When the Fuzzy-ARTMAP network is used in a learning problem situation, it is trained until it can classify correctly all the training data.

The mathematical development and the algorithms for the processing of a Fuzzy-ART and Fuzz-ARTMAP neural network are found, respectively in [7] and [8], and applied in [9].

III. Methodology

This study was conducted under the Federal Institute of Education, Science and Technology of Mato Grosso - IFMT. The universe of interest are the students enrolled in the Colleges of Technology (CT) in Automation and Industrial Control, Control Works, Internet Systems, Computer Networks and Executive Secretary at IFMT, attending presential courses in the morning, afternoon and evening. The choice is justified in view of the high dropout rates, verified by previous statistical studies, noting that CT Automation and Industrial Control, reached a dropout rate of 62.46% from 2004 to 2010 [1].

In the implementation and pilot test of the intelligent system proposed, the neural network was fed with data belonging to all the students enrolled in the CT, from 2004 to 2009, making a total of 1650 samples for the training phase, constituting the basis historical data. For diagnosis 499 samples, of data from the students enrolled in 2010 and 2011 were used [1].

The database for prediction of the risk group prone to evasion consists of the students' characteristics such as demographic factors, and factors internal and external to the school. These characteristics were lifted from data from the selection processes at IFMT, the Q-Selection, which stores the answers of the socioeconomic questionnaire filled by the students on the day they enroll for the selection examination and the Q-Academic, system of integrated academic management, where all the academic history of the IFMT students is concentrated [1].

The input vector of the Fuzzy ARTMAP neural network is composed by 16 parameters considered as significant for the school dropout prediction and the output of the network constituted by two classes, evasion and non-evasion. The input-output vector pairs are represented in the binary coding, being the input vector composed by 41bits and, the expected response represented by 1 bit. A summary of the input and output variables of the neural network can be visualized in Table I.

IV. Fuzzy ARTMAP Neural System Proposed for the Evasion Prediction

The data that involve the study about evasion, are sometimes, complex, subjective, non-linear, inter-related and keep in themselves the specificities inherent to the different levels of teaching, courses and institutions that one can analyze, thus choosing ANN, as among its potentialities there is the possibility of processing problems where complex and unknown relations are involved among different sets of data and, also adjust the relations of non-linearity between the input and outup variables [1]. More specifically, the Fuzzy ARTMAP network, where the training is carried out in a supervised and self-organized way, with possibility of continued learning, as implemented in [10]. Its application potential aims at solving several problems of classification and of approach of non-linear functions and showing prompt reply.

The input of the Fuzzy ARTMAP network proposed is represented by vector a (input of the module ARTa) and its

TABLE I. Composition of input and output vectors

	Characteristics of the Subvectors of a and y			
	Position	***Name***	***Abbreviation***	***Size***
Variable of the Input Vector (a) of the Network	a_1	Gender	Gen	1 bit
	a_2	Age Group	Ag	3 bits
	a_3	Ethnicity	Etn	3 bits
	a_4	Marital Status	MSt	3 bits
	a_5	People/House	P/H	3 bits
	a_6	Family Income	FI	3 bits
	a_7	Has a Computer	Comp	1 bit
	a_8	Parents' Education	PE	3 bits
	a_9	School of Origin	SO	3 bits
	a_{10}	Self-Evaluation	SEv	3 bits
	a_{11}	Where From	WF	1 bit
	a_{12}	Dist. School-Residence	DistSR	3 bits
	a_{13}	Means of Transport	MT	3 bits
	a_{14}	Work	Wk	3 bits
	a_{15}	Study Shift	SS	2 bits
	a_{16}	Students/Classroom	S/C	3 bits
Output Vector (y)	y	Non-Evasion	NEv	1 bit
		Evasion	Ev	

desired output, in the training phase, represented by vector b (input of the module ARTb), being these ones described in the following way:

$\boldsymbol{a} = [\boldsymbol{a}_1\ \boldsymbol{a}_2\ \boldsymbol{a}_3\ \ldots\ \boldsymbol{a}_{16}]$

$\boldsymbol{b} = [\ b\ ]$, where: $\boldsymbol{b}$ = "0" ou "1"

The subvectors $\boldsymbol{a}_1\ \boldsymbol{a}_2\ \boldsymbol{a}_3\ \ldots\ \boldsymbol{a}_{16}$ of the vector a (Table I) are lines vectors which contain the binary representation of the students' characteristics. Each bit corresponds to one component of the corresponding vector.

The network output is represented by the activity layer vector F2 (y) and provides answers in the binary coding with 1 bit, being that code "1" corresponds to students' evasion and code "0" to non-evasion, defined as follows:

y = [y] (Fuzzy ARTMAP network output)

The model proposed in this study consists of an intelligent system (flowchart shown in Fig. 1) for the study of students' evasion in the IFMT, using an Fuzzy ARTMAP Neural network [2-4], Logic Fuzzy and/or Dempster-Shafer's Theory of Evidence - TDS.

The information of the database is pre-processed and converted into a binary database. The essentially binary conception is considerably worthwhile, because the neural network presents a more efficient behavior (prompt and better quality of answers) and allows the extraction of knowledge in a continuous way (continued training), seeking for a better adaptation to the conditions of the institution and improvement with time.

In the phase of the neural analysis, if the answer is negative in relation to evasion, no action is adopted; just the register of the mentioned information is performed. If the answer of evasion is positive, the following step corresponds to a better discrimination about the quality of information (fine analysis) based on the use of Fuzzy module and/or of the Dempster-Shafer's Theory of Evidence. Later, solutions that aim to revert students' evasion will be proposed (proactive action).

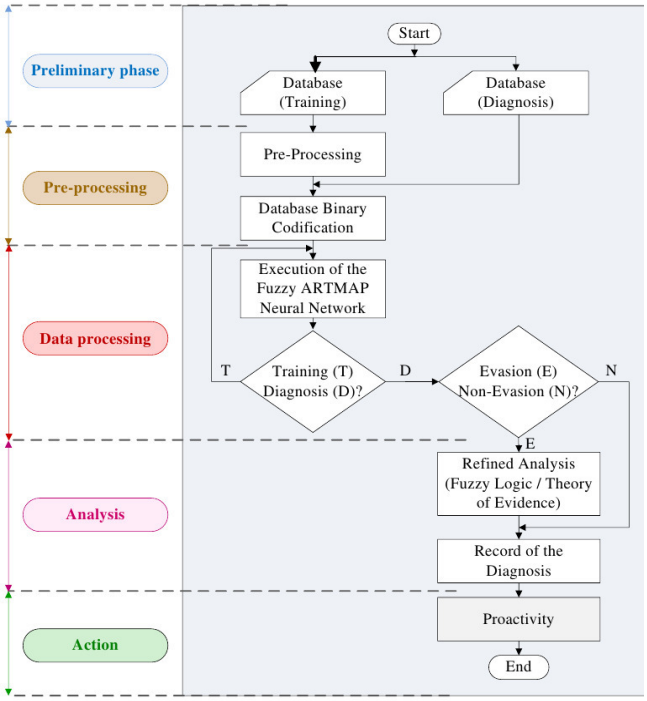

Fig. 1 Flowchart of the structure and sequence of development of the neural system proposed to perform the prediction of the evasion group risk

V. Application and Analysis of the Results

The intelligent system, using a Fuzzy ARTMAP, Neural Network proposed to make the prediction of the risk group of students prone to evasion, was implemented and tested with a database composed by 1.650 rows and 42 columns in the training phase of the network. In the validation and diagnosis phase of the network a sample with 499 lines and 41 columns was used, about 30% of the training samples. Each line represents the inputs standard vector and its corresponding desired output, in the training. The data of the columns from 1 to 41 represent the attributes correspondent to vector a, input of the module ARTa. In column 42 are represent the desired outputs, vector b (input of the module ARTb) of the Fuzzy ARTMAP neural network.

The parameters used in the database processing are specified in Table II.

After the network training five simulations were performed, based on data for the diagnosis, for the validation of the model proposed, being that, in one of them the samples were processed in a naturally way and the other in a randomized way.

The results of the processing were compared and analyzed, using a criterion, called "voting criterion" [7], "0" or "1" of higher incidence for each of the inputs. The result of higher incidence constitutes the output of the neural network.

Later, comparing the output from the network with the real situation of each sample of the group of students analyzed, it was possible to investigate the coincidence of the evasion ("1") and non-evasion ("0") among the samples processed and the reality.

After concluding the phases of the processing of database through an Fuzzy ARTMAP Neural Network and respective analyses necessary to the understanding of the behavior in relation to students' evasion and non-evasion, the results were compiled and, briefly, shown in Table III.

TABLE II. Specification of the Parameters: Fuzzy ARTMAP Network

Parameters and References Values	
Parameters	***Values***
Choice parameter ($\alpha > 0$)	0.001
Training rate ($\beta \in [0,1]$)	1.0
Vigilance parameter module ART_a ($\rho_a \in [0,1]$)	0.2
Increasing in the vigilance parameter ρ_a (ε)	0.05
Vigilance prameter module ART_b ($\rho_b \in [0,1]$)	0.999
Vigilance parameter module inter-ART_{ab} ($\rho_{ab} \in [0,1]$)	0.7
Vigilance parameter in the match tracking ($\rho_{amat} \in [0,1]$)	0.75

TABLE III. QUANTITATIVE AND PERCEPTUAL RESULTS OF THE DIAGNOSIS OF SCHOOL EVASION PREDICTION

Diagnosis of School Evasion	Quantitative and Percentages Values: Output of Network					
	Evasion		*Non-Evasion*		*Total of Samples*	
	Number	*%*	*Number*	*%*	*Number*	*%*
Samples	90	100	409	100	499	100
Corrects	88	97.8	295	72.1	383	76.7
Errs	2	2.2	114	27.9	116	23.3

The reading, interpretation and data analysis in Table III show that: of 499 samples, 90 of them corresponded to the evaded students and, 409 students who had concluded or attending a course, that is, not-evading. The proposed system identified 88 evasion possibilities and ignored 2, with a margin of success of 97.8%. Among the 409 samples of non-evasion, the Fuzzy ARTMAP network proposed recognized 295 samples in this situation and did not hit the target in 114, getting it right in 72.1% of the cases. It reached the global accuracy of 76.7%, finding correctly 383 samples of a total of 499.

The quantitative results of the previous diagnosis of the students with possibility of evasion can be perceived, more clearly in the graphs of Fig. 2.

Considering the experiment done and consistency of the results obtained, it can be inferred that the intelligent system, using Fuzzy ARTMAP, neural network proposed to identify the students prone to evasion, is a model with a significant degree of reliability and expresses accurately the situation in which the students analyzed are.

VI. CONCLUSION

This study presented an innovative method to identify, in a proactive, continued and accurate way, the students considered to belong to the risk group of school dropout, using Fuzzy ARTMAP neural network.

The analysis of the results showed that the proposed system is satisfactory, with global accuracy superior to 76%, and with a significant degree of reliability, making possible the early identification, even in the first term of the course, the group of students likely to drop out. The anticipated identification of this group of students enables the institutional education, alongside the multidisciplinary team to adopt strategic, proactive and individualized measures with the aim of reducing or even mitigating the students' evasion.

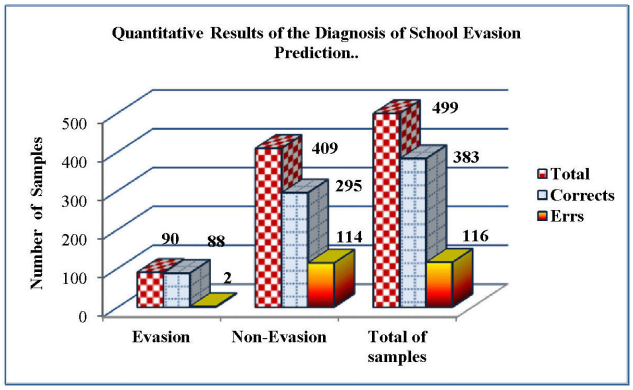

Fig. 2 Qualitative result of prediction of school evasion

REFERENCES

[1] V. Martinho, "Intelligent System for Prediction of Group Risk Evasion Student," PosGraduate Program in Electrical Engineering, Electrical Engineering Department, UNESP, Ilha Solteira - SP, 2012. (in Portuguese).

[2] G. A. Carpenter, S. Grossberg, and K. Iizuka, "Comparative performance measures of fuzzy ARTMAP, learned vector quantization, and back propagation for handwritten character recognition," International Joint Conference on Neural Networks, vol.1, pp. 794-799, 1992.

[3] G. A. Carpenter, S. Grossberg, N. Markuzon, J. H. Reynolds, and D. B. Rosen, "Fuzzy ARTMAP: A neural network architecture for incremental supervised learning of analog multidimensional maps," IEEE Transactions on Neural Networks, vol. 3, pp. 698-713, 1992.

[4] G. A. Carpenter and S. Grossberg, "A self-organizing neural network for supervised learning, recognition, and prediction," Communications Magazine, IEEE, vol. 30, pp. 38-49, 1992.

[5] S. Haykin, Neural Networks: Comprehensive Foundation: Prentice Hall, 1999.

[6] S. Grossberg, "Competitive learning: From interactive activation to adaptive resonance," Neural networks and natural intelligence, Massachusetts Institute of Technology, pp. 213-250, 1988.

[7] G. A. Carpenter, S. Grossberg, and D. B. Rosen, "Fuzzy ART: Fast stable learning and categorization of analog patterns by an adaptive resonance system," Neural Network, vol. 4, pp. 759-771, 1991.

[8] G. A. Carpenter, S. Grossberg, N. Markuzon, J. H. Reynolds, and D. B. Rosen, "Fuzzy ARTMAP: A neural network architecture for incremental supervised learning of analog multidimensional maps," IEEE Transactions on Neural Networks, vol. 3, pp. 698-713, 1992.

[9] V. Martinho, C. Nunes, C. R. Minussi,, "A new method for prediction of school dropout risk group using neural network Fuzzy," XV International Conference on Artificial Intelligence, Las Vegas, 2013, in press.

[10] S. C. Marchiori, M. C. G. da Silveira, A. D. P. Lotufo, C. R. Minussi, and M. L. M. Lopes, "Neural network based on adaptive resonance theory with continuous training for multi-configuration transient stability analysis of electric power systems," Applied Soft Computing, vol. 11, pp. 706-715, 2011.