ARTIFICIAL INTELIGENCE TECHNIQUES IN AN EVALUATION AND DECISION SYSTEM FOR ECONOMIC ACTIVITY

Nicolae Morariu

"Ştefan cel Mare" University of Suceava, nmorariu@eed.usv.ro

Abstract:
The paper presents the integration of some artificial inteligence techniques within an evaluation and decision taking system in economic activity. The proposed intelligent system incorporates an expert system and a learning machine. As learning machine, a software product realised by the author in Visual Basic for Application in Excel is presented. The product was designed to classify and recognize patterns by means of two methods of artificial intelligence, namely: pattern-recognition and multi layer perceptron. In problem solving, the two methods can be applied either jointly or independently. The final section of the paper presents an example of how the program applies to the diagnosis of the evolution in time of certain economic indexes within a specific area.

1 The overview of the system

The proposed intelligent system for evaluation of the decisions concerning the economic activity incorporates an expert system and a learning machine.

1.1 The expert system

The expert system is [5] un informatic module that stores the knowledge in production rules format using logical and symbolical facts. The quantitative inputs data are converted into qualitative variables for the knowledge base. Let x_i with $i=1,n$ the values for a time variable parameter $x(t)$ and the regression ecuation

$$x(t) = a.t + b \qquad (1)$$

Firstly, the a and b coefficients are determined. The qualitative value will be determined as follows:

- if |a| ≤ ε then the evolution of the parameter will be considered constant;
- if a > ε (ε > 0) then the evolution of the parameter will be considered positive;
- if a < -ε (ε > 0) then the evolution of the parameter will be considered negative;

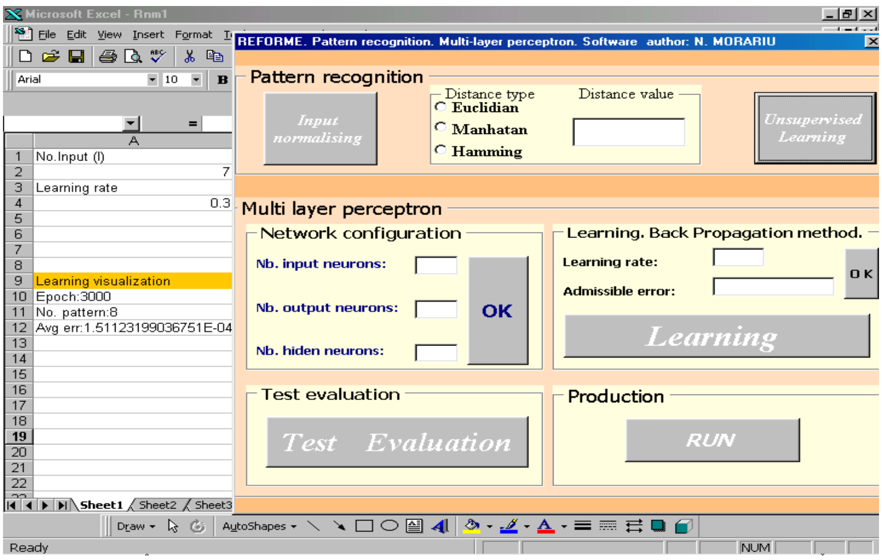
where ε is a threshold value.

The inference process is based on forward chaining and backward chaining algorithm and is oriented to find out the value of a special fact called expertise goal. This fact is a qualitative variable having as possible interpretation the following: economic decrease, stagnation, economic increase.

1.2 The learning machine

The learning machine called REFORME is a program conceived in Visual Basic for Application in Excel for the classification and recognition of patterns, using pattern-recognition techniques [6] as well as a multi layer perceptron with error back-propagation [1], [3]. The user interface of the program is illustrated in the following screen capture:

Fig.1. The program-user interface



The program consists of two modules:

1. pattern recognition;
2. multi layer perceptron;

and enables joint usage of the two pattern-classification and recognition technologies for a shared set of data taken from the Excel program. The data representing the patterns are transferred in the data sheet no.3 in which the rows represent the patterns and the columns represent the features defining the patterns. Since the number of patterns and their features is automatically established by the program, the data have to be transferred under the form of a list (without empty columns and rows in the domain of the list).

The module “pattern recognition” performs:

- normalization of the inputs, using the method of domain adjustment;
- unsupervised classification, using the threshold algorithm with minimal distance classifier for the type of selected distance (Euclidean, Manhatan, Hamming) and specified threshold distance. The resulting categories will be encoded by means of sub-unitary numbers that can represent given exits for the module “multi layer perceptron” for supervised learning where the sigmoid activation function with values situated within the (0,1) range is used.

The normalization and classification results are registered in the data sheet no.3.

The module “multi layer perceptron” performs:

- network architecture specification (network configuration);
- supervised learning, using the method of error back-propagation;
- network testing and evaluation;
- pattern recognition based on the results obtained after the learning phase.

The network configuration consists of:

- specification of the number of I neurons from the input layer;
- specification of the number of H neurons from the hidden layer;
- specification of the number of O neurons from the output layer.

Depending on the values communicated for the data, stored in sheet 1, the weight random arrays WI(HxI) and WO(OxH) in (-1,1) range is generated, corresponding to the links between the input layer and the hidden layer and the hidden layer and the output layer, respectivelly. The weight arrays will be stored in sheet 1.

For the supervised learning phase, the rate of learning and admisible error is communicated. Either a number of epochs until the error condition fulfils or a specified number of epochs will be completed. In passing from one epoch to another, the patterns are randomly chosen and the weight matrixes are replaced by the new weights obtained once the error back-propagation method was applied. Once a specified number of epochs are completed, the learning phase can be carried further on from the preceding point with a new number of epochs and possibly with a new learning rate. The average error obtained at the end of each epoch appears constantly on the screen in a visible section of the data sheet 1, thus enabling permanent monitoring during the learning phase, as illustrated in fig.1.

The testing and evaluation phase consists in evaluating the results of the learning phase for a specified set of testing and evaluation patterns.

As far as the pattern-recognition phase (RUN) is concerned, the network instructed in the previous phase will be used to classify a specified set of patterns.

2 Case study. Diagnosis of the evolution of certain economic indexes within a specific area.

Data concerning the evolution in time of certain economic indexes within a specific area have been considered:

T1. The evolution of indexes between 1993 and 2000

Index Name	1993	1994	1995	1996	1997	1998	1999	2000
I1. Joint investments (mil. lei)	875	2767	2800	3000	2980	3020	3100	3100
I2. Private investments (mil. lei)	5960	23934	24000	24220	24300	24000	24400	24000
I3. National gross product (%)	86	89,4	87	93	92	90	90	95
I4. National gross product per inhabitant (%)	83,9	87,3	85	91	90	88	88	93
I5. Industrial production index (%)	100	100	100	100	94,2	91,5	86,1	82,5
I6. Unemployment rate (%)	8,0	8,9	10,0	11,0	12,4	13,7	13,5	12,0
I7. Number of commercial businesses	10013	14501	17012	19746	22983	19469	22987	23130

The input data are transferred in an Excel data sheet as follows:

Fig.2. Transferring input data

B1 = (A=Learning, T=Test evaluation, P=Recognition, AT=Learning+Test, X=Unutilised)

	A	B	C	D	E	F	G	H	I	J
1	Id. Pattern	(A=Le	I1	I2	I3	I4	I5	I6	I7	
2	11993	A	875	5960	86.00	83.90	100.00	8.00	10013	
3	21994	A	2767	23934	89.40	87.30	100.00	8.90	14501	
4	31995	A	2800	24000	87.00	85.00	100.00	10.00	17012	
5	41996	AT	3000	24220	93.00	91.00	100.00	11.00	19746	
6	51997	A	2980	24300	92.00	90.00	94.20	12.40	22983	
7	61998	AT	3020	24000	90.00	88.00	91.50	13.70	19469	
8	71999	A	3100	24400	90.00	88.00	86.10	13.50	22987	
9	82000	AT	3100	24000	95.00	93.00	82.50	12.00	23130	
10										

Each row in the data sheet represents a pattern defined by the values of the 7 indexes on a one-year basis. These data are processed by means of the procedures specific to the above-mentioned methods used in evaluating the evolution tendency of the indexes. In the case of the output data a qualitative variable representing the result of the diagnostication is considered. The modalities of this variable have been encoded by means of real numbers, having as possible interpretation the following: 0.1 economic decrease, 0.2 stagnation, 0.3 economic increase. Once the data are normalized and classified (unsupervised recognition by means of threshold algorithm) with the Euclidean distance as classifier for threshold value=1, the input patterns are distributed in three classes as follows:

Fig.3. Pattern-classification through threshold algorithm

B1 = (A=Learning, T=Test evaluation, P=Recognition, AT=Learning+Test, X=Unutilised)

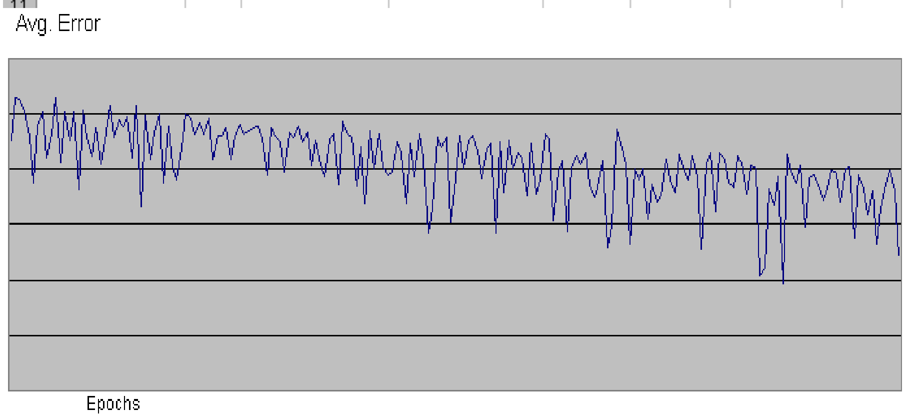
	A	B	C	D	E	F	G	H	I	J
1	Id. Pattern	(A=Le	I1	I2	I3	I4	I5	I6	I7	Class
2	11993	A	0	0	0.00	0.00	1.00	0.00	0	0.1
3	21994	A	0.850337	0.974729	0.38	0.37	1.00	0.16	0.342151	0.2
4	31995	AT	0.865169	0.978308	0.11	0.12	1.00	0.35	0.533582	0.2
5	41996	A	0.955056	0.990239	0.78	0.78	1.00	0.53	0.742014	0.2
6	51997	AT	0.946067	0.994577	0.67	0.67	0.67	0.77	0.988793	0.3
7	61998	A	0.964045	0.978308	0.44	0.45	0.51	1.00	0.720897	0.3
8	71999	A	1	1	0.44	0.45	0.21	0.96	0.989098	0.3
9	82000	A	1	0.978308	1.00	1.00	0.00	0.70	1	0.3
10										
11	Min		875	5960	86	83.9	82.5	8	10013	
12	Max		3100	24400	95	93	100	13.7	23130	
13										

A multi layer perceptron with 7 inputs (the 7 indexes), 6 neurons on the hidden layer and an output layer is defined. During the neuronal network training phase (supervised learning), using the back-propagation algorithm, starting from the outputs representing the classes obtained previously by means of pattern-recognition, with a learning rate of 0.3, after the completion of 4000 epochs, we obtain the calculated outputs and their corresponding errors as follows:

Fig.4. The result of network learning after the completion of 4000 epochs

B1 = (A=Learning, T=Test evaluation, P=Recognition, AT=Learning+Test, X=Unutilise

	A	B	C	D	E	F	G
1	Id. Pattern	(A=Le	Expected Output	Network's Answer	Error	Nb.Epochs	Learning rate
2	11993	A	0.1	0.103725104	6.94E-06	4000	0.3
3	21994	A	0.2	0.186980153	8.48E-05		
4	31995	A	0.2	0.205930719	1.76E-05		
5	41996	AT	0.2	0.226612303	0.000354		
6	51997	A	0.3	0.266761346	0.000552		
7	61998	AT	0.3	0.289022095	6.03E-05		
8	71999	A	0.3	0.314172909	0.0001		
9	82000	AT	0.3	0.308062032	3.25E-05		
10			Er.medie:1.51123199036751E-04				



The resulting weights are as follows:

Fig.5. The weights obtained after the completion of 4000 learning epochs

L20 =

	A	B	C	D	E	F	G	H
1	WI(HxI)							
2	0.833923	0.742285	0.213957	-0.07683	-1.23017	1.264145	0.225589	
3	0.724357	0.774209	0.713833	0.049798	1.459135	0.771283	0.747772	
4	0.254515	0.816654	0.900392	0.083997	1.402119	0.163152	0.440322	
5	0.618945	-0.1148	0.579247	0.454608	0.990735	0.372376	0.50653	
6	0.196111	0.203928	0.817086	0.811677	1.529912	0.860441	0.853301	
7	0.47951	0.973234	1.014967	0.279268	-0.47656	0.43364	1.214504	
8	WO(OxH)							
9	1.742393	-0.95773	-0.95487	-0.72872	-1.09462	1.106895		
10								

The initial data have been used for learning (75% of the obtained data) and testing (25%). In order to evaluate the performances, the complete set has been considered (the learning together with the values of the testing set). Once built and trained, such a network can be used in simulated prognosis and estimation.

References:

[1]. Herve Abdi, Les Reseaux de Neurones, Universite de Bourgogne,1993
[2]. Ioan Andone, Sisteme inteligente hibride. Teorie. Studii de caz pentru aplicații economice. Ghidul dezvoltatorului, Editura Economică, Bucureşti, 2002
[3]. D. Dumitrescu, Hariton Costin – Inteligența Artificială. Rețele neuronale teorie şi aplicații, Ed. Teora Bucureşti, 1996
[4]. IEEE Transactions on Computers vol.50 nr.9 sept.2001, Neural Networks - Stohastic Neural Computation pp. 891-905.
[5]. Şt.Gh.Pentiuc, Nicolae Morariu, ş.a., Intelligent System for Prognosis and Estimation of Economic Decisions at Districtual Level, Advances in Electrical and Computer Engineering, Faculty of Electrical Engineering "Stefan cel Mare" University of Suceava, vol.1(8), nb.1(15), 2001, pp. 44-47
[6]. Romul Vancea, Ştefan Holban, Dan Ciubotariu, Recunoaşterea Formelor Aplicații, Ed. Academiei R.S.R. 1989
[7]. Prefectura Județului Suceava – Cartea verde a județului Suceava, vol. 1- III, 1998
[8]. Prefectura Județului SuceavaProgramul de dezvoltare economică şi socială pe anul 2001, 2001