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An Application of Intelligent Systems to Support Credit Analysis: a Real Case Study

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***Abstract*—Financial corporations need increasingly to manage in an effective way their credit portfolio, avoiding losses to their customers and shareholders. With competition growth among banks in the fight for clients, they saw the contraction of profit margin associated to credit operations, being forced to enlarge their client´s base to improve earnings. To this end, it is necessary that corporations develop fast and reliable methods to aid in the decision making process. This paper describes, through Fuzzy Logic methods, and Kohonen Neural Network expert systems to automate the decision making mechanism, typical of financial institutions working in the personal credit segment .**

Keywords— Credit Analysis; Kohonen Neural Network; Fuzzy Systems

I. INTRODUCTION

The word credit can have different meanings and uses. Credit can mean trust and it can be defined as the act of disposing a determined value on behalf of another with the promise of receiving this value in the future. Financial institution, may have this disposal as one of their objective, in other words, they may dispose values to their clients in exchange for a future payment [1, 2].

In commerce, credit facilitates the purchasing transactions, allowing customers to buy the act and pay in parcels. Some companies obtain better financial results (profit with payment in parcels) than an operational result (profit with merchandise sales); in the industry, as in the commerce, credit also facilitates the purchase of industrialized products, permitting to increase the number of potential clients and in banks it is one of the PONTA of their basic business - financial intermediation. The bank collects money with customers in possession of available resources and passes it to borrowers. The bank's profit is achieved through the difference between what it receives from the borrower and how much it pays to the investor [3].

Politics influence decisions (associated to credit) concerning a company's macro environment. The aimed result as a consequence of credit operations must be clear, in other words, policies must be direct informing which products will be negotiated and in which markets the company will operate.

The Central Bank is a monetary and financial market regulating agency. When companies elaborate their credit policies, should always pay attention to the current law. Each detail in the operation must be verified carefully so that it doesn't transgress any laws, exposing the company to unnecessary risks.

The company must define which is its main public (a person, an artificial person or both), geographic area of performance, products (leasing, CDC, FINAME etc.) and in which markets it will be present (personal credit, credit to the companies, automobiles, big vehicles, real estate etc.).

What is the result the company expects to have? Which are the business-oriented objectives the company is looking for? The answers for these questions will have a strong influence in the credit policy. Companies with "more aggressive" objectives tend to have riskier credit policies. The level of risk exposition and the expected result (return) will guide the credit policy [4].

Credit analysis consists of attributing values to a group of factors that allows the emission of a report about a specific credit operation.

A subjective value is emitted for each individual factor (positive or negative). If the set of factors presents a smaller number of positive values than negative ones, the tendency is a favorable credit concession report.

The credit concession process for a person or an artificial one is very alike, they all have a very similar flow. A person's source of income and its expenditures can be of short or long term. Often, the lack of control, the sprouting of unexpected expenditures or other factors, result in a need to search for an extra supplement to fill this budget's gap. A credit professional mission is to analyze if the proponent

deserves to have the institution's trust to grant them the needed resources [5, 6].

There is also a situation where the proponent is looking for resources to invest. The analysis is somewhat different, but the principles are the same. There are factors of capacity and character analyzing them is possible to emit a report. The factors' gives us an idea of the customer's probable behavior. Their past is analyzed and their future behavior is being predicted. Thus, through this procedure credit is granted to those that demonstrate greater and better possibilities to honor their commitments

Another factor of vital importance is the guarantee. A credit operation is carried through based on guarantees for, they are essential factors in a credit analysis, they can give a certainty that, in of case of an accident, the invested capital will have a faster return.

Credit analysis use computers as an instrument. It is possible to know the profile of probable a good payer, through a statistical database. We cannot forget the information obtained by the validation and analysis of the presented documents by the borrower - whom desires to carry through with a credit operation [6, 7].

All these factors permit a credit analysis with greater security. With the idea to facilitate and to rationalize the concepts of a credit analysis we presume the mathematical model below:

a) credit analysis
character + capacity + patrimony + guarantee = < or > risk

b) character
punctuality + restrictive + identification = < or > risk

c) capacity
age + civil state+ source of income + work period = < or > risk

d) patrimony
existence + market value + origin's identification = < or > risk

e) guarantee
liquidity + market value + correct formalization = < or > risk

II. KOHONEN NEURAL NETWORK

The Kohonen model is a neural network characterized as feed forward and unsupervised that uses simple adaptive neurons to receive signals from a space event, consisting of measures or data - as frequency or situation [8]. The Kohonen model has neurons from the output layer disputing for the representation of the information presented to the input neurons. If there is a winning neuron, it is readjusted to better answer the received stimulation [8, 9]. Inside this unsupervised model, not only the winner, but its neighbors are also adjusted. The Kohonen mechanism functions as follows: the synaptic weights initiate contending low random values, and a input signal x (with values that represents any information), it is provided for the net without specifying the desired output (characteristic of the unsupervised network) [9]. The input signal x is described as:

$$x = [x_1, x_2, x_3, \dots x_n]^{t\,n} \quad (1)$$

According to the input signal, an output neuron y will have to answer better for the respective input, and, then, it will be the winner. This makes this neuron gone off every time this specific input is presented to the neural network. The winning neuron y, and its neighbors (Vy), will have its synaptic weights adjusted to answer better the presented x input. The net is only considered trained after all the sets of training are presented to the net, and once the training criterion has been satisfied. After the training phase, the neural net is tested. This phase is similar to the training phase; the difference is that the neurons' weights will not be modified. In order to refine the test, the network will be able to receive an input and not only the presented facts but others that did not belong to the set of training. Recognizing the test's adequate input, the net is considered well trained [10, 11, 12].

Each neuron at the net represents a network output, in other words, if the net possess a total of 13 neurons in the output layer, there will be, consequently, 13 possible outputs for any amount of inputs the net is submitted to. Another basic aspect, is that the output neuron is widely connected with the inputs, what this means is that, having 9 inputs, it will have, consequently, 9 synaptic connections between each input neuron and the 9 points at the output layer [13].

In output neuron, there will only exist the calculation answer between the inputs and the synaptic weights. The net's knowledge depends on the weights of its connections [14].

The definition of a neuron's neighbors has great importance. If, for example, a neuron is i, its neighbors can, then, be defined as i + 1 and i - 1.

At the beginning, the set of neighbors is extensive and they are not well defined. The best auto-organization occurs when the set of neighbors starts extensive and diminishes with the time. Thus the neighborhood can be defined as a time-variable.

The set of neighbors initiates extensive and slowly it decreases in its size (0<t1<t2)

The Kohonen algorithm is originally from the auto-organization, a similar process to what occurs with the brain. In the algorithm, the outputs are widely connected with the inputs and, after many facts are presented, the weights will specify groups or centers that answer in a similar form. These weights will be organized so that, topologically, it will be sensible to inputs. The output neuron (y) will be commanded in a natural way.

The neurons adaptation is crucial for ordained formation; therefore, although a neuron can be

affected independent of another, it is the entire set that represents the information. The adjustment of the synaptic weights occurs in the following form, first the winning neuron for the presented input must be found, in other words, which neuron possesses the smaller Euclidian distance.

In each learning stage, the neuron with the best answer should be adjusted to answer the input, and all the neurons inside the Vi neighborhood will be modified together. The neurons outside the neighborhood's subgroup will not be modified. Neuron's adaptation is very simple. Basically, the difference between the two vectors (x and w) is added to the difference to the original weights vector (w):

$$w_i(t+1) = \begin{cases} w_i(t) + \alpha(t)[x(t) - w_i(t)] & if \rightarrow i \in V_n(t) \\ w_i(t) & if \rightarrow i \notin V_n(t) \end{cases} \quad (2)$$

The stop criteria can be:

a) when the term arrives in zero ,for there will not exists alterations in the selected neuron's weights. One of the things that has been done is the establishment of different decrement periods for different t moments during the training. This means that, a different flow, in a different fluctuation period of the same training may occur;

b) 300 iterations for each neuron in the output layer.

This means that, existing 100 neurons in the output layer, it must be aroused to 30000 iterations, so that, the set is ordained adequately. These 30000 iterations means that it will pass 50000 times in the training set towards the neural network. However, we stand out that, these parameters are not rules; they are specific researcher's recommendations from the observed results. Nothing prevents it from having success with less or more iterations.

A Kohonen neural network, has the following training stages:

a) initialization of the N neurons' weights with low random values (low in relation to input values);

b) initialization of the Vi ray for each neuron's neighborhood (it is common for Vi to equal the net's size);

c) presentation of the input data to the net;

d) the calculation of the Euclidean distance between the input and each output neuron 's weights;

e) Selection of the winning neuron, that is, the neuron with the smallest distance (the smallest dj (t));

f) update of selected neuron's weights, together with all the neurons inside a neighborhood defined by Vi(t) where i Vi(t) and 0 < i N.

The (t) term is an advance term that must ranged between 0 and 1 (0 (t) 1). It is recommended to start with a high value and to decrement it along time.

g) If necessary, all neurons neighborhood's ray has to be modified. This modification will imply in a reduction of Vi(t) ray.

h) If there exists a fact that belongs to part of a training set that was not presented to the network, return to item c;

i) if the number of iterations reached the specified number at the beginning, finish this phase; on the contrary, carry through with a new training set iteration returning to item c.

When the net's general order is finished, is necessary to know which are the winning neurons, so that they appropriately receive their label due. As label, it can be understood the name of fact. For example, if the set of training possesses 3 facts, each one of them with a specific name, is certain that the neurons indicated for each fact will also represent the exact name. Therefore it is associated to the neuron the name of the fact witch it was pointed to. If the names of 3 trained facts were "orange", "banana" and "apple" as resulted of the neural network (after the ordinance phase), there would be at least 3 neurons, one called "orange", another called "banana" and a third one called "apple". Nothing prevents that more than one neuron indicates the same fact, in other words, having the same distance. If this occurs, the net will have n neurons with the same name.

The Kohonen network, even after it has been trained, can pass through a fine adjustment of the neuron layer. This method is used to increase the neural net's efficiency to recognized the standards for which it was trained [10, 13].

There exists many types of adjustments but, the adjustment used in this work was the adjustment type: LVQ1 (Learning Quantization Vector type 1). The adjustment must be made after the net has been trained (commanded) and correctly labeled. In order to do that, it is necessary to prepare a new set of training that contains already known inputs by the net.

All adjustment stages must proceed in the same manner just like the initial training was made, with a few small differences.

One tries to make the number of adjustment iterations smaller than the number of ordinance iterations in the neural net (previous phase). The (t) scaling must initiate with a low value, since the intention is to have another great neuron ordinance, but only a small adjustment in certain network's cells.

The (t) scaling begins with 0.01 or 0.02. The (t) reduction tax, during the adjustment iterations, must be sufficiently small (of the reduction tax type =/100,000). The neighborhood must be ignored, remaining a portion of the unchanged neurons.

III. Fuzzy Systems

The first notions of Fuzzy Logic were developed by Jan Lukasiewicz (1878 - 1956) in 1920. Instead of using rigid rules, and a line of logical reasoning based on premises and conclusions, Lukasiewicz attributes pertinence degrees {0, ½, 1} To classify vague and imprecise concepts. Later, it expanded this set to all values contained in the interval [0,1]. However, the first publication on Fuzzy Logic is dated 1965. Its author was Lotfi Asker Zadeh, a professor at the University of California at Berkeley [15].

Fuzzy Sets and Fuzzy Logic provide the basis for the generation of powerful problem solving techniques with a wide applicability, especially in the areas of Control Engineering and Decision Making [15, 16].

The strength of Fuzzy Logic stems from its ability to infer conclusions and generate responses based on vague, ambiguous, and qualitatively incomplete and imprecise information. In this respect, Fuzzy systems have the ability to reason similarly to humans. Its behavior is represented in a very simple and natural way, leading to the construction of understandable and easy maintenance systems [17].

Conventional systems theory is based on algebraic, differential or differential equations ("crisp" mathematical models). For some types of systems, mathematical models can be obtained, such as electromechanical systems, since the physical laws behind the process are well understood and defined. However, on a daily basis, we encounter numerous practical problems, where it becomes difficult to obtain an acceptable level of information necessary for us to do the physical modeling. Moreover, this task is time-consuming and costly. We can find these systems in the chemical and food industries, in Financial Institutions, in Biotechnology, among other areas. A large part of these systems can only be obtained through the knowledge of experts who participate directly in the process in question. This knowledge can often be vague or imprecise to be expressed through mathematical models. However, if it is used linguistic variables, it is possible to describe the functioning of the system, in the form of "IF - THEN" rules [17, 18].

IV. Case Study

The Morada Bank is a financial credit institution, of the Morada Group, present for more than three decades in the credit market, it has the tradition of constituting assets with good quality and highly sprayed, its is recognized for its ethical position, experience and its technical domination. The bank is present is a delineated niches of the market, with emphasis is the following areas: Personal Loan, Direct Consumer Credit, Credit Cards Administration, Daily pay-dated Check Discounting, Financing of Automobiles, Banking transactions for Artificial People, Investments in CDBs and as resources agent for the BNDES.

Amongst the bank's products it offers personal credit, which is a credit line offered by banks and financiers, regardless of the destination given to the money. Therefore, it is a different line of DCC (Direct Credit to Consumer), tied to the purchase of specific goods. To demand this loan, the interested party fills a registration form and the financial institution evaluates the consumer's risk level, to know their possibilities of paying correctly or becoming a defaulter. Many banks, already have lines of personal loan previously approved based on the consumer's description, and inform the client via mail, if they granted the loan.

Most personal credit operations are performed through with pre-established interest rates, although, operations with post-fixed interest rates also exist. The interest rates are usually smaller than the ones charged by credit cards, DCC and personal checks. The client can offer guarantees to the bank, a few examples are: their real estate or car, with this guarantee they aim to reduce the charged interest rates - smaller the risk smaller will be the interest rate.

A. Information Systems and Data Mining

All financial institutions use monetary assets, and periods for transactions. The observance strong governmental regulations, the use of advanced technologies, and risks acceptation as well (Anthony et all, 2002).

A credit control system has the objective of offering support to manage loans requests using a credit analysis and after its approval they should accompany the customer's behavior towards the contract. The information concerning customers, contracts as well as the payment's behavior are stored in the credit control system's data base, also on the payment behavior

The data base allows the assembly of models that predicts customers' profile and their chance of becoming defaulters in the future, even though at the moment they were conceded credit they had conditions to pay it. These models can then be installed in call centers to supply information to credit analysts. This enables the bank to give more attention to those clients that have a bigger risk level.

The first phase of this model's creation, was the use of the great operational data that enabled the creation of the behavior model, a data mining process was performed with the objective to transform these data and information into knowledge, in order to make the correct decisions.

Much knowledge is hidden in the vast amount of data available in business databases and it is with Data Mining that it can turn this raw data into valuable information to aid decision making.

The difference between Data Mining and statistical techniques lies in the use of the data itself for the discovery of the standards and not in the verification of hypothetical standards.

Databases store knowledge that can help us to improve our business, and traditional techniques only allow us to verify hypotheses that are approximately 5% of all the relationships found by these methods. Data Mining can discover the other unknown relationships: the remaining 95%. That is, it can be said that conventional techniques "speak" to the database, while Data Mining "listens" to the database.

Data Mining did not come to replace traditional statistical techniques, being an extension of statistical methods that are in part the result of a considerable change in the statistical community. The increasing power of computers coupled with the lower costs and the growing need to analyze huge data sets with millions of rows allowed the development of techniques based on the exploration of possible solutions by brute force

The main purpose of Data Mining is the extraction of valuable information from the data, for the discovery of "hidden gold". This "gold" is the valuable information the data contains. Little changes in the strategies coming from the discoveries of the Data Mining tools, can turn into significant differences in the company box. With the increased use of Data Warehouses, Data Mining tools have become paramount.

The implementation of a Data Mining system can be divided into six interdependent phases so that it reaches its final objectives:

Understanding the Problem - The initial phase of the project should aim to identify the goals and needs from a perspective of the problem, and then convert them to a Data Mining application and an initial plan to "attack" the problem.

Understanding the data - This phase has as main activity the extraction of a sample of the data to be used and to evaluate the environment in which they are.

a)Data preparation - Creation of data extraction, cleaning and transformation programs for use by Data Mining algorithms. It is at this stage that the data are adapted to be inserted into the algorithm chosen for processing.

This stage was of fundamental importance so that the process of data mining could generate the rules of association. More than 50% of the time spent on research was spent in this preparatory stage.

• Deletion of unnecessary items, fields (columns) and instances (lines) for the analysis: In this step some data was deleted from the spreadsheet generated by the BW query in order to reduce quantity and improve processing quality. All items that did not include purchases of IT products, columns containing data deemed not necessary for any type of analysis, and lines with inconsistencies were excluded.

• Filling in blank fields: Some fields, when migrating from the Data Warehouse, appeared in the worksheet with zeroed values, making case-by-case analysis necessary with the appropriate action. Either the item was deleted, or identical values were assigned to the other identical items.

• Codification and standardization of the description of the items: In order to guarantee impartiality in the analyzes of the associations presented after the application of the association rules, two tables were elaborated codifying the buyers and the suppliers, replacing in the worksheet the names of the buyers and Of companies by their respective codifications.

• Enrichment of data: In the first phase of data enrichment, the diversity of forms of descriptions in the database for the same product was perceived, which could not guarantee significant results after the application of the rules by WizRule.

To use Kohonen Neural Network in this case study, customers were separated in two categories: payers and defaulters and within these categories they were grouped according to their common characteristics such as: profession, age, civil state, income and income's level of commitment.

These results were the inputs of a neural network that has used this information and then has extracted historical knowledge to predict customers' future behavior according to their characteristics.

To formulate a Fuzzy System this paper has based on five input variables of extreme importance in decision making: age, previous experience, income, income commitment and financial value. Each variable was assigned a "range", which is the delimitation of the same, that is its minimum and maximum values respectively.The output variable was a grade that returns values between zero and one (0,1). It was decided that individuals with a value above 0.45 would have the credit approved, while individuals who returned values below 0.45 would have the credit denied.

B. Results using Koronen Neural Network

Initially a variance analysis was used to verify the existence of differences (or not) between groups (sex, age, income's range, profession, loan's value, form of payment and debt) and a gathering analysis to identify representative groups for the study case. The same analysis was used to obtain the groups with elevated, low and average insolvency, and the group that paid their contractual obligations.

The gathering analysis used the Euclidian distance to measure the similarities between groups. The following groups were accepted:

Sex: female | male

Profession:

autonomous without a diploma

autonomous with a diploma

pay roll employee without a diploma

pay roll employee with graduation

retired or with a pensioner

public server

Age:

between 18 and 25 years

between 26 and 35 years

between 36 and 45 years

between 46 and 50 years

between 51 and 60 years

above 60 anos

Civil state:

Married | bacheler | other

Income:

between 500 and 1500 reais

between 1501 and 2000 reais

between 2001 and 2500 reais

between 2501 and 3000 reais

between 3001 and 4000 reais

above 4000 reais

Desired loan:

between 100 and 500 reais

between 501 and 1000 reais

between 1001 and 2000 reais

between 2001 and 3000 reais

between 3001 and 4000 reais

between 4001 and 5000 reais

Each group is identified by a Kohonen neural network with different parameters and learning rates. The network's hit level is of 100%. After the identification of each group the data goes another Kohonen network that classifies the client's probability of insolvency. The result is a table 1.

TABLE I. KOHONEM NEURAL NETWORK RESULT

Sex	**profession**	**age**	**civil state**	**income**	**desired loan**	**Kohonen neural network result**
female or male	Autonomus with or without a diploma	between 18 and above 60 years	married, single or other	between 500 and 2000 reais	between 500 and 2000 reais	high solvency
female or male	Pay roll employee with or without a diploma	between 18 and above 60 years	married, single or other	between 500 and 2000 reais	between 500 and 2000 reais	high solvency
female or male	Autonomus with or without a diploma	between 18 and above 60 years	married, single or other	between 2001 and 4000 reais	between 500 and 3000 reais	average solvency
female or male	Pay roll employee with or without a diploma	between 18 and above 60 years	married, single or other	between 2001 and 4000 reais	between 500 and 3000 reais	Average solvency
female or male	Autonomus with or without a diploma	between 18 and above 60 years	married, single or other	between 3001 and 4000 reais	between 1500 and 3000 reais	average solvency
female or male	Public server with or without a diploma	between 25 and above 60 years	married, single or other	between 1001 and 4000 reais	between 1500 and 3000 reais	Low solvency
female or male	Retired or pensioner with or without a diploma	between 41 and above 60 years	married, single or other	between 2001 and 10000 reais	between 1500 and 4000 reais	paid contractual obligation

It can be seen from table 1 that high solvence are people that are autonomus with or without a diploma and pay roll employee with or without a diploma, with the age between 18 and above 60 years old, independent of civil state, earning between 500 and 2000 reais with desired loan between 500 and 2000 reais.

Average solvency are people that are autonomus with or without a diploma and pay roll employee with or without a diploma, with the age between 18 and above 60 years old, independent of civil state, earning between 2001 and 4000 reais with desired loan between between 500 and 3000 reais and another group earning between 3001 and 4000 reais with desired loan between between 1500 and 3000 reais.

The low solvency are people that are public server with or without a diploma with the age between between 25 and above 60 years old independent of

civil state, earning between between 1001 and 4000 reais with desired loan between 1500 and 3000 reais.

The last group are people that pay only contractual obligation that are retired or pensioner with or without a diploma earns between 2001 and 10000 reais with desired loan between 1500 and 4000 reais.

To validade the results of this Kohonen neural network it was taken a hundred clients out of sample and this sample was tested in this net. The neural network hit 97% of real data.

C. Results using Fuzzy System

The result is presented in figure 1.

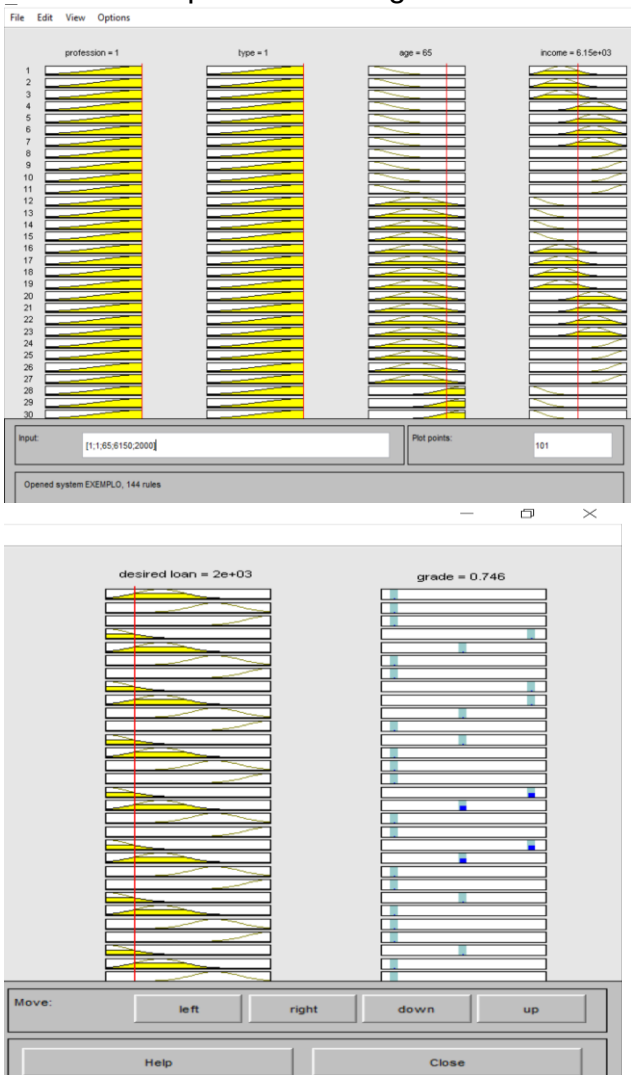

Fig. 1. Fuzzy System Result

In this case the person had already taken out a loan previously, and paid as the contractor. This is a positive factor from the point of view of the professional credit analyst.

The individual was committing only 5% of their monthly income with the payment of the parcel. For a professional credit analyst, this individual has a certain "slack" in his or her budget to shoulder this obligation.

At age 65, it is common for a person to no longer support their possible children, and in many cases, they can even count on their help if they plan their spending poorly. In the analyst's view, this is a good thing.

The income of the individual in question is considered high by the analysts, and is always a positive point in the analysis of credit for individuals. This factor, together with a low commitment of monthly income, makes this individual seen by the market as a "good payer".

The amount financed in this case belongs to the most defaulting band: between R $ 1,000.00 and R $ 2,000.00. However, the other variables related to this individual caused the model to approve its credit. The system was tested with forty real cases and had right results in 98%.

V. CONCLUSIONS

This paper has shown that intelligent systems are very useful to support decision making. The credit analyst always judge alone based in its experience and some rules of its companies.

In this case study the bank had a great earn using this system because many people

that were rejected without this support decision system were accepted using it. That is the bank was loosing money for not giving credit to who would pay.

Another intelligent system that was presented also supports decision of credit analyst giving a grade to approve or not the client.

The systems had used different inputs and output just to show the relevance of intelligence systems in decision making.

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