DonnishJournals 2041-3472

Donnish Journal of Business and Finance Management Research
Vol 1(2) pp. 009-018 August, 2015
http://www.donnishjournals.org/djbfmr

Original Research Article

An Analysis of Applications and Possibilities of Neural Networks (Fuzzy, Logic and Genetic Algorithm) in Finance and Accounting

Muhammad Mehtab Azeem[1]* and Ayub Mohammad[2]

[1]Department of Economics and administrative Science, Istanbul Aydin University, Turkey; Francois Rabelais University-France and International Institute of Paris-France.
[2]Department of Business Administration, International Institute of Paris, France.

Accepted 27th July, 2015.

There are problems in Finance and Accounting that cannot be solved easily through traditional techniques - for example, bankruptcy prediction and strategies for trading on stock exchanges. In these cases, an alternative is the use of computational intelligence methods. This article examines empirical research published in international journals between 2007 and 2014 that present studies on the application of neural networks, fuzzy logic and genetic algorithms to Finance and Accounting area's problems. The goal is to identify and quantify the relationships established between the available technologies and the problems studied by the researchers. Analyzing 278 articles, it was realized that the most used technique is the artificial neural network. The most researched applications are of Finance, especially those related to stock market (forecast stock prices and indexes).

Keywords: Neural networks, Genetic algorithms, Fuzzy logic, Finance, Accounting.

LITERATURE AND INTRODUCTION REVIEW

Artificial neural networks (artificial neural networks or RNAs) are fundamentally based on algorithms derived from research concepts about the nature of the brain used for cognitive tasks, such as learning and optimization. Of the three techniques whose applications will be reviewed by this article (neural networks, fuzzy logic and genetic algorithms), artificial neural networks is the oldest. The pioneering work on neural networks is that of McCulloch and Pitts - A Logical Calculus of the Ideas Immanent in Nervous Activity - published in 1943.

The RNAs can "understand" themselves, the characteristics of a problem, using their learning one set of examples whose response is already known (Muller, Reinhardt, 1990). We predict that increasing amounts of privacy-preserving financial data will be publicly available in the near future due to collaboration between practitioners and researchers, and that this should lead to more investigations of data techniques that can be applied to privacy preserving data (Anuj Sharma, Prabin Kumar, 2012).

The concept of fuzzy logic (fuzzy logic or LN) was introduced by Lotfi Zadeh in 1965, as a way to reduce the complexity and explain systems (Cox, 1998). This idea remained virtually unknown to the general public by the end of the 1980s, when the Sendai subway adopted a system based on the LN - the Automatic Train Operator (ATO) - and there were several companies that had the goal of developing and marketing products based on this technology. Although commercial interest be cooled, it is now possible to find the fuzzy logic applications in very different areas that they came - as in Finance and Accounting, objects of study of this article.

Genetic algorithms (GAs), in turn, are techniques of parallel search (Nanda; Pendharkar, 2001), beginning with a set of possible solutions and through special operations (evaluation, selection, crossover and mutation) gradually evolve toward more promising solutions.

As well as neural networks have emerged inspired by the functioning of the brain, genetic algorithms were inspired in evolution, natural selection and genetic (Nunez-Letamendia, 2002). These algorithms basically depend on a function that evaluates the quality of a particular solution to the problem - and this function can be obtained even for difficult problems to be solved by conventional techniques.

Each of computational intelligence methods discussed in this article - artificial neural networks, fuzzy logic and genetic algorithms - has multiple applications. The detection capability of the neural network presented standards, for example, allows its use in applications as diverse as diagnosis of breast cancer studied by Übeyli (2007), and pricing of financial derivatives, studied by Montagna et al (2003).

Corresponding Author: Muhammad Mehtab Azeem. E-mail: mehtabazeem@yahoo.com

Even within the areas of Finance and Accounting, objects of study of this article, applications are quite diverse, including the stock performance forecast, credit analysis and forecasting of bankruptcy - which are the most common. In the case of neural networks and genetic algorithms, this flexibility arises, at least in part from the fact that many of these models do not require prior knowledge of the problem to be solved. And being in its origins, a way to express uncertainty, fuzzy logic can be used in various types of problems where the variables, by their very nature, cannot be defined exactly.

This situation is quite common in Finance and Accounting. Precisely because of this flexibility offered by computational intelligence, a particular problem or application can enable more than one approach. The forecast price of a financial asset, for example, can be performed either with the use of fuzzy logic as with artificial neural networks. Even in cases where there is more than one viable option, it is expected that items related to prioritize each application methods that are more effective.

Therefore, the analysis of recently published articles can show the preferred techniques for each application, as well as emerging trends that may become dominant soon. Among Brazilian researchers, the application of intelligent systems in these areas is a reality. Streit and Borenstein (2009) analyze the regulation of the financial sector through a model based on agents; and the behavior of these agents was simulated by fuzzy rules built by analyzing the content of newspapers and interviews with experts. This is therefore a hybrid approach that combines fuzzy logic with econometric models and a simulation based on agents. Faria et al. (2009) use neural networks to predict the Bovespa's behavior, finding that it was possible to predict the rate of change in signal at 60% of the time.

We conclude that this degree of effectiveness is similar to that achieved in developed markets using the same techniques, and it is possible to develop decision support systems exploiting this prediction of the artificial neural networks.The aim of this paper is to analyze the international academic articles using empirical methods of computational intelligence (fuzzy logic, neural networks and genetic algorithms) to address problems related to finance and accounting, in January 1, 2007 period to 31 December 2014.

To achieve this goal, we identified and analyzed the finance and accounting applications that have been addressed with the use of computational intelligence methods and subsequently quantified the frequency of each of the possible combinations of method and application. It was also made a more detailed analysis of hybrid algorithms and its evolution; finally, they identified the journals that published articles in the period.

It is hoped that this analysis reveals the importance of intelligent information systems and the impact they are having on the international scientific production. This article also shows the connections that can be made between artificial intelligence and the needs of users, revealing the opportunities for researchers and users of these systems. And, to quantify and classify the scientific production in these areas, the article also provides an overview of existing research possibilities, identifying problems yet explored and that can be developed with the use of artificial intelligence.

THEORETICAL FRAMEWORK

Although they are all classified as computational intelligence, the three methods discussed in this article are different in nature and in the way we solve problems. Therefore, this topic will be presented, in brief, the basics of each of these techniques.

Artificial Neural Networks

With this technique, from basic units - neurons (neural units) - networks are built in a certain neural unit which receives inputs from other neurons. All received entries are multiplied by their synaptic weight. These products are added, resulting in an output value that, after being transformed by an activation function, is passed on to the next layer of neurons (Calderon; Cheh, 2002). Various neurons may be organized into layers (layers) forming a neural network. Before a neural network can be useful, it needs to be trained, that is, must "learn" the problem. The learning process determines the appropriate synaptic weights for each neuron, such that the output obtained by the last layer of neurons are the nearest possible to the desired outputs problem that must be solved.

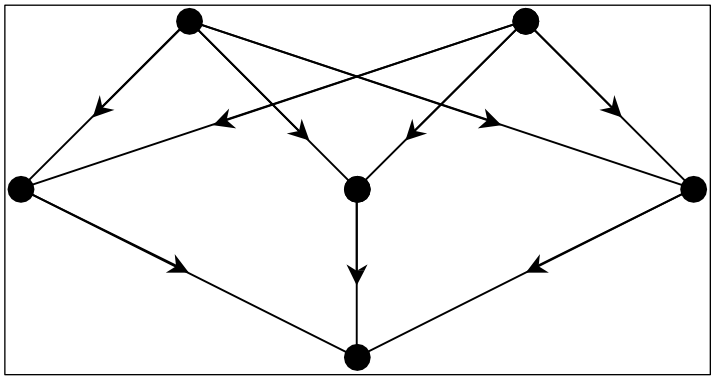
In Figure 1, there is a neural network of three layers of feed-forward type, also called perceptron. The upper layer is called the input layer having two variables; the lower layer is the output layer. The intermediate layers (in this example, there is only one) are called hidden layers (hidden layers). An artificial neural network with the architecture shown in this example could for example be trained to perform the XOR Boolean operation ("exclusive OR"). The usefulness of neural networks is due to its ability to "learn" using training data (examples), and then generalize from observations. RNAs are particularly useful in problems that are not known in depth, and can even deal with data sets that contain distortions, noise and irrelevant data (Hwang; Lin, 2000).

Fuzzy Logic

In conventional logic (binary), an element belongs or does not belong to a certain set, and never lies between these two possible states. This is a way to simplify an inherently complex world, but - argue proponents of fuzzy logic - this simplification ends up distorting reality (GRINT, 1997). Fuzzy logic is a method to express uncertainties more consistently through the fuzzy sets: rather than simply belonging or not belonging, an element can have varying degrees of relevance to a set. The fuzzy sets (fuzzy sets) are functions that map, on a scale from zero to one, this relevance of a particular element to the set.

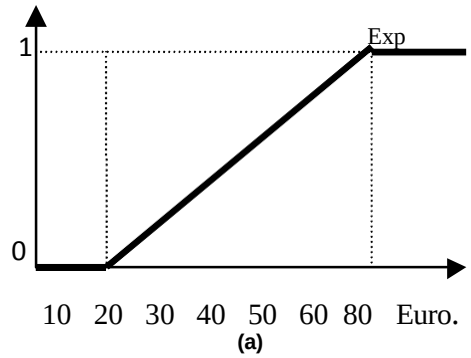
The value zero indicates that the element does not belong to the set while the value one means that the element is completely representative assembly; between these two values indicate intermediate degrees of relevance. Figure 1 shows a classic set and a fuzzy set representing a product of relevance to all products which are expensive, according to its value. In the first graph, a product that costs 50 one belongs to this group, but a product that costs 40 one does not belong. There is an abrupt transition between belonging and not belonging to the set of expensive products.

Figure 2b shows a situation in which the transition between belonging or not to the group of expensive products is smoothly performed by fuzzy logic. In this case, a product that costs 50 Euro is fairly expensive, and not just expensive, as with classical logic. Similarly, a product that costs 30 Euro is a little expensive. There are endless possibilities of membership between 0 and 1. With fuzzy sets we can perform various operations - the basic ones are intersection, union and complement - and with inference rules (policies), to create models that help in decision making.

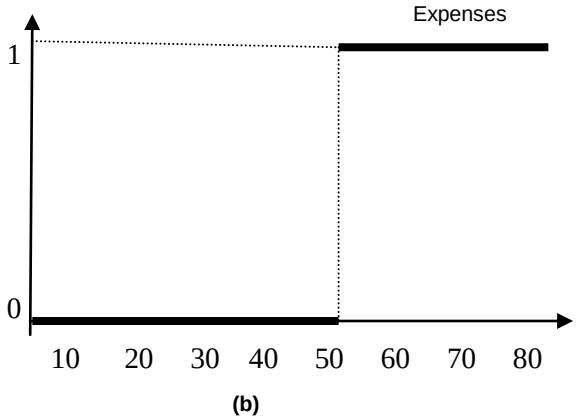


Source: Adapted from Müller and Reinhardt (1990).

Figure 1. Diagram of a neural network with three layers



(a)



(b)

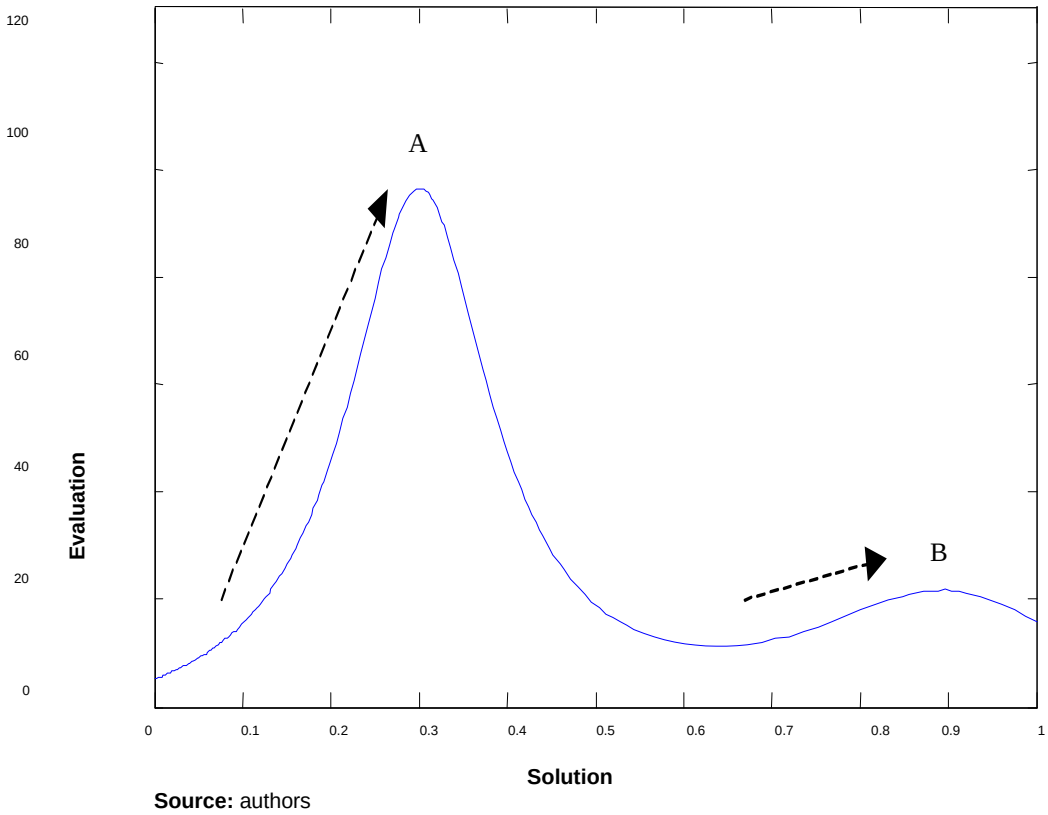
Source: authors.

Figure 2. Classical set and fuzzy set example

Genetic Algorithms

The basic operation of a genetic algorithm (GA) was first described in the mid-1970s by John Holland, and its first applications - as well as fuzzy logic - emerged in Engineering. To perform the search for optimal solutions, GAs first generates a set of random solutions to the problem to then calculate (using an evaluation function) the quality of each of these solutions. Then, through mechanisms of reproduction, combining the best solutions, creating new solutions that are possibly more appropriate than those that gave rise to it. The new set of solutions is again evaluated. Playback and evaluation are repeated until the set of solutions can not be improved.

This process is shown diagrammatically in Figure 3, which represents all possible solutions to a problem (the horizontal axis) and the quality of each of these solutions (the vertical axis). A first set of solutions is generated, and through a GA, it is expected that some of these solutions evolve gradually toward the point A, called global maximum. There is the possibility of solutions eventually focusing on point B, which is the local minimum. This risk, however, can be reduced with the adoption of strategies to ensure the heterogeneity of the solution set.



Source: authors

Figure 3. Set of solutions

Remember that in addition to the playback, you can exchange information between two chromosomes (solutions) - technique called crossover - or change pieces of a solution, simulating the genetic mutations found in living things. Its operation, as explained, causes the FAs to be suitable for analyzing a large solution space (through the samples present in the initial population randomly generated), subsequently concentrating the areas showing the most promising results (Rafaely; Bennell 2006).

Related work

Found were similar bibliometric articles published, but only involving artificial neural networks. The applications of fuzzy logic and genetic algorithms have not been the subject of a bibliometric study, possibly due to the relative scarcity of articles on these methods.

One of the articles aimed to examine historical trends of the articles published on neural networks applied to finance in the period 1971-1996 (WONG; SELVI, 1998). This study examined 64 articles and detected a decline in the number of publications in 1995 and 1996 after a rapid rise from 1991 to 1994. Similarly, Fadlalla and Lin (2001) examined the application of Neural Networks in Finance only. This article chose to examine in detail a sample of 40 articles, also observing the characteristics of neural networks adopted.

We came to the conclusion that the most common control strategy is the error backpropagation (BP), adopted by 26 of the 40 articles, and it is common that you use only a hidden layer (which occurs in 29 articles). More importantly, it was discovered that on all items - except for one - the RNA fared better than traditional statistical methods. It was concluded that the investments are concentrated in a few areas, and there are other areas that could also take advantage of these techniques. Mochon et al. (2008) expands the scope of its analysis to the so-called soft computing- What are the techniques that try to replicate the ability of the human mind to apply reasoning modes that are approximate rather than accurate.

This definition encompasses RNAs and fuzzy logic and genetic algorithms, plus some other probabilistic techniques. Instead of performing a bibliometric analysis, this paper aims to show the different applications of these tools, concluding that they adapt perfectly to the needs of the world of finance. Mochon et al. also concludes that this research area is still gaining popularity, and do not expect the trend to be reversed soon. It found another correlative work in the area of Accounting - more specifically, auditing and risk, also involving RNAs developed by Calderon and Cheh (2002).

A qualitative study was done on the articles, including analysis of data sources, variables and used architectures. These authors also point to the practical use of these technologies: events such as the collapse of Enron show that there are fuzzy and nonlinear patterns that can not be detected by traditional methods.Wong, Lai and Lam (2000) analyzed the application of artificial neural networks in business, covering a total of 302 articles between 1994 and 1998 a fall in the number of articles was detected in 1998, and it was suggested that this could indicate either a decrease in interest as being a consequence of the emergence of new journals that were not included in the survey.

METHODOLOGY

The methodology was divided into three parts: the first refers to the collection of articles - involving the search itself and the places where the items will be obtained. The second part deals with the analysis and classification of the work and preparation of data for further analysis. Finally, it shows the limitations of the work.

Collection of articles

As one of the specific objectives is to relate the methods of computational intelligence in business applications, the keyword search was divided into two areas: methods and applications. The terms relating to the technical - neural, genetic and fuzzy - belong to the first group. In the second group, at first we used the finance and accounting words. In the first stage of the research, the elements of these two fields were grouped in pairs, and the search was conducted joining the elements of each pair through the Boolean AND operator. The articles obtained in this step were analyzed and classified, the most common topics, so identified, that is, specific applications in Finance and Accountancy that have been studied for two or more articles.

These topics were used to prepare an expanded list of keywords, which contained stocks, forex, exchange, bankruptcy, commodities, interest rate, credit, derivatives, options, portfolio, fraud, auditing, bank and business. This list was also combined with the terms neural, genetic and fuzzy, and these pairs were made with new search the databases. The search was carried out in two databases available on the Journals Portal Capes: Science Direct and Pro Quest. There are other databases such as EBSCO Host and the CSA, which also feature articles in Science the area of Information and Technology. Although important, these databases are not object of this work.

On ScienceDirect, an advanced search was made in the title, abstract and the articles of keywords from 2007 to 2014, limited to the following subjects: business, management and accounting; computer science; decision sciences; economics, econometrics and finance. This limitation prevents the search returns articles on neuroscience or gene, for example. In ProQuest, an advanced search covering summons and summary was made between 01/01/2007 and 31/12/2014, limited to full-text articles and academic publications.

Analysis and classification

Once obtained the search result, proceeded to read the abstract (and the full article, if necessary), observing if the item used any of the techniques under study, the proposed application was in Finance or Accounting, and an empirical study was presented. These conditions are met, we proceeded to the classification. First, each item was classified as the techniques used - RNAs, LN and GAs. And if different methods of computational intelligence to be used in the same model, it received the additional classification of hybrid. Articles which compare different methods were ranked in both methods, but not as hybrids.

Later, the articles were classified according to the area to which the problem was related - Finance or Accounting. None of the work was classified in both areas; in the specific case of work on capital structure (which could be classified both in Finance and in Accounting), it was decided to classify them as Finance jobs. This decision is justified by the fact that both work on capital structure found have been published in journals of Business and Finance, but not accounting.

The most common specific applications and work were then classified into one of these applications have been identified. Those who did not fit into any of these most common applications are grouped in the other category. After the analysis, the categories that had less than seven articles were eliminated, and their jobs were relocated to the other category. Remember that this classification, even more than the others, is subjective. Some problem categories are:

a) Bankruptcy: covers not only articles that specifically addressed bankruptcy prediction, but also those who classify the company into categories according to their financial health - as the work of Agarwal, Davis and Ward (2001);
b) Actions: beyond the forecast performance of individual company stocks, includes indexes, funds and IPOs. Articles related to commodities, forex (foreign exchange) and derivatives are not included.
c) Derivatives: instead of creating categories for each type of existing financial derivatives, it was decided to group them under the generic label of articles on derivatives. This includes options (on stocks, indices and currencies), futures, warrants and weather derivatives.
d) Credit Analysis: includes analysis of candidates for loans provided by banks and government institutions, evaluation of credit card solicitations and articles about sovereign credit analysis.

In some cases, the same article had to be classified in more than one category as the implementation. Qi and Zhang (2001), for example, analyzes the selection of time-series forecasting models addressing three series with different characteristics: stock indexes, foreign exchange and T-bills. Therefore, this work was classified simultaneously in equities, foreign exchange and interest.

Limitations

The different methods of computational intelligence can be applied in various ways. The neural network term, for example, covers different training algorithms and various possible configurations for a neural network. A more detailed analysis of each of these techniques, however, is beyond the scope of this article. The boundaries between the different ratings for the algorithms may be diffuse. They found methods related to the subjects of study, but were excluded from the study; a case of particular importance is the genetic programming. Despite using an enhancement process similar to the solutions of genetic algorithms, the structures of the solutions analyzed are different.

In the case of genetic algorithms, the solution is represented by a set of fixed-size character; in genetic programming, the solution is a hierarchical tree representing operations performed on constant or variable (Chen et al, 2007). There are many items that were not included because they are outside of the defined period. This is an important limitation because a quick search for fuzzy and accounting in ProQuest, for example, found 20 results before January 1, 2007; another search for neural and finance, in the same database, returned another 32 articles.

This work is limited to review articles that present real examples. This means that studies using numerical examples (fictitious) to demonstrate a technique were not

considered. There are also articles using computational intelligence methods to build artificial (or simulated) markets, where agents modeled according to certain theoretical assumptions make their decisions.

The conclusions reached by the latter class work may have practical applications, but this research sought to limit to articles that show directly applicable methods the Finance and Accounting Area problems. The limitations set forth herein may cause significant bias: empirical data on stock exchanges, futures and commodities are readily available in specialized databases; other data are obtained with much less easily.

ANALYSIS OF RESULTS

After the selection, that is, excluding repetitions and items out of the methodological limitations, remaining 112 articles in ProQuest and 166 in ScienceDirect, totaling 278 different jobs. Of these, 186 were from the field of Finance and 92 Accounting.

Rate per year

It can be seen that the trend in the first three years (2007-2009) was down, reaching the number of 32 and 33 articles in 2009 and 2011 (Figure 4). One of the reasons that may have contributed is that not in the ProQuest articles published in the International Journal of Intelligent Systems in Accounting, Finance and Management in 2010.

It is assumed that there was a gap in the edition of this journal, which reappeared in 2011 with the name of Intelligent Systems in Accounting, Finance and Management. Starting this year, the trend in the total number of items is growing. It is worth noting that from 2012 to 2014, there was an increase in the use of fuzzy logic, genetic algorithms and hybrid models, while a drop in the number of articles on artificial neural networks. This may indicate a shift of interest from the academic community - possibly due to the fact that neural networks have already been widely explored, with a total of 193 articles during the period under review.

It can be seen from Table 1, the Expert Systems with Applications is the journal that published more articles on computational intelligence applied in Accounting and Finance. Importantly, however, that 38 of the analyzed articles were found in different journals that presented during the study period, only one article. This means that there are other journals that occasionally can publish articles involving computational intelligence applications in the Business area. As an example, there is an article that deals with pricing derivatives through neural networks, published in a magazine in Physics (Montagna et al, 2003). This suggests the hypothesis that the application of computational intelligence in Finance and Accounting is multidisciplinary.

Rating method and application

To analyze the preference of the authors of an area by one of computational intelligence methods, we should first get the number of articles related to each application. And, as can be understood from Table 2, the majority of analyzed articles (68.22%) are the Finance area.

The selected items can also be classified according to their specific applications, as shown in Table 3. Only four of these items were classified in more than one application: one is framed simultaneously in credit analysis and bankruptcy; two in shares and interest; the last was ranked stocks and exchange.

It can be noticed that applications related to actions received a lot of attention in the articles analyzed. This group includes works that address individual company stocks and stock indexes (e.g, Ibovespa and S & P 500). In both cases, Article normally seeks to predict the level of prices in the next period or identify the trend of price movement (up or down).

One of the studied articles aimed to predict the closing price of the DJIA (Dow Jones Industrial Average) using external factors (ie, the model was not limited to use past prices) (O'connor; Madden, 2006). External factors used were the price of oil (WTI /Cushing/ crude oil) and exchange rates (USD / YEN, USD / GBP, USD / CAN). Also used were derived technical indicators of the DJIA. In the test set, we obtained an annual return on investment of 21.10% - the transaction costs are included.

As a comparison, the market return was 13.03%, and a simpler neural network - which used only past quotes - had return of only 8.03%. This shows that neural networks are not a solution in themselves; variables must be carefully chosen, and its performance depends on the environment in which they are used. Very efficient markets - such as the New York Stock Exchange - their performance will not always be exceptional.

A credit analysis also got a lot of attention. This category of work is not limited to the analysis of requests for credit cards or bank loans; one of the found articles aimed to predict the risk of default in the context of international trade. A fuzzy model was used with 3344 Asian companies, and tried to identify companies that have problems to honor payments of its imports (Tang, Chi, 2005). When comparing the model based on fuzzy logic with a logit model, it was observed that the first is more sensitive, i.e, it has superior performance in detecting delinquent companies.

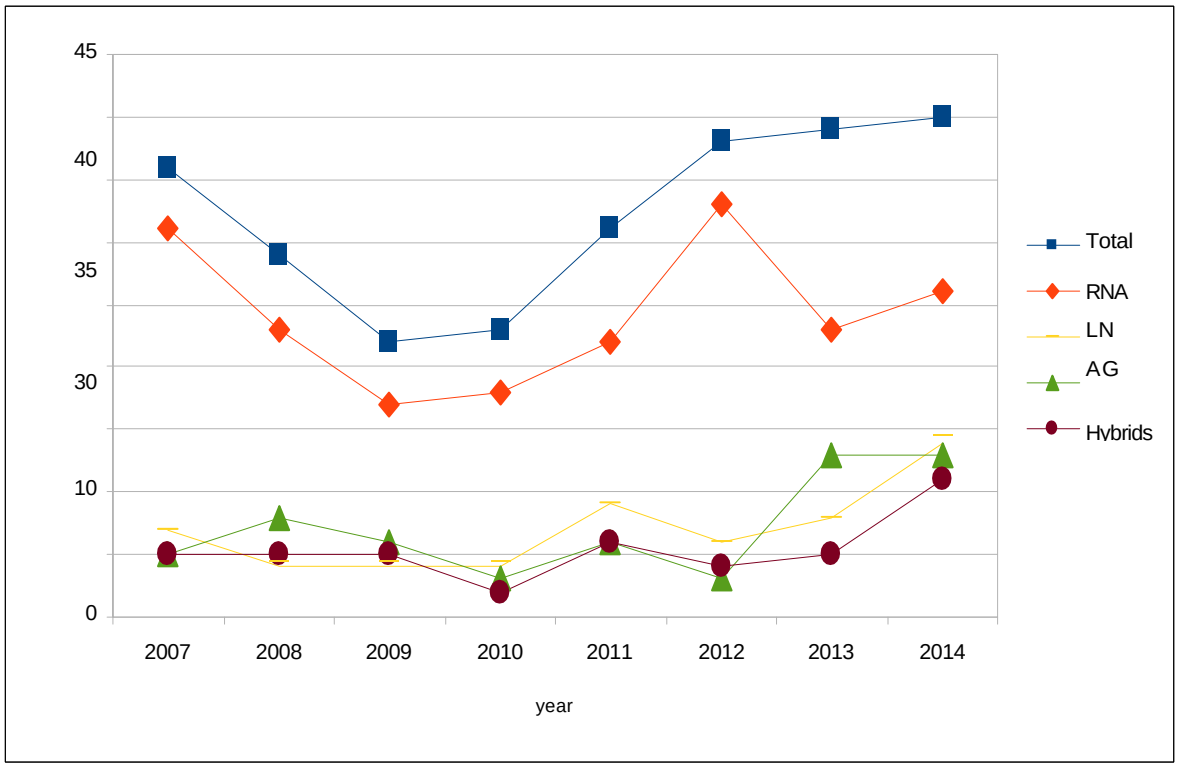
The logit model, by contrast, have greater success in the ranking of companies that offer no risk of losses due to non-payment. This shows that the choice of model depends on the characteristics of the problem; if the cost of erroneously rejected claims is greater than the losses due to default, then the logit model is most appropriate.

As it wants to observe the most common techniques in each area, the same article can be classified in more than one method, whether or not hybrid. Therefore, the total values of each area were ignored - it would not be in accordance with the total of 278 articles analyzed. Data were organized in Table 4.

Observing table 4, it appears that artificial neural networks are the most widely used method, corresponding to 74.81% of the analyzed articles; and that the hybrid algorithms are much less frequent, with only 13.57%. The preference for neural networks is a little sharper in the accounting area, in which 78.57% of the articles use them. In Finance, this percentage is 73.30%.

In the case of fuzzy logic, there is a considerable difference: this technique is present in 21.02% of the work of the Finance area and 22.62% of the work of the Accounting area. Hybrid algorithms are still quite rare, and their presence is somewhat more common in the works of Finance, being used in 17.05% of them. To investigate if there were more common techniques for each type of problem, a new analysis was made across applications and methods, as shown in Table 5. In this case, models using more than one method is classified solely as hybrids.

It is noticed that the articles on stock exchanges favor the artificial neural networks, which are used in 56.96% of the work; Articles that more use neural networks are those on derivatives and futures.



Source: Research Data. Rating journal

Figure 4. Total number of articles published per year

Table 1. Journals most frequently published articles

Periodic	Frequency
Expert Systems with Applications	52
European Journal of Operational Research	20
Computers & Operations Research	15
Fuzzy Sets and Systems	13
International Journal of Intelligent Systems in Accounting, Finance and Management	12
Neuro computing	9
Intelligent Systems in Accounting, Finance and Management	8
The Journal of the Operational Research Society	8
Computational Economics	7
Derivatives Use, Trading & Regulation	7
Journal of American Academy of Business	7
Journal of Forecasting	7
Omega	6
Others	107
Total	278

Source: Research data.

Table 2. Applications

Application	Frequency
Finances	186
Accounting	92
Total	278

Source: Research data.

Table 3. Common specific application

Application	Frequency
Actions	79
Exchange	37
Credit analysis	35
Bankruptcy	30
Portfolio management	18
Derivatives and futures	16
Interest	14
Fraud	6
Others	28

Source: Research data.

Table 4. Techniques used in Finance and Accounting

Method	Finances	Accounting	Total
RNA	129	64	193
LN	37	19	56
AG	44	13	57
Hybrids	30	12	42

Source: Research data.

Table 5. Techniques used in the most common applications

Technical	RNA		LN		AG		Hybrids	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Actions	45	56,85%	7	8,87%	11	13,95%	16	20,27%
Exchange	25	67,58%	2	5,45%	1	2,72%	10	27,04%
Credit analysis	24	68,56%	4	11,45%	2	5,70%	6	17,13%
Bankruptcy	17	56,68%	3	10,00%	5	16,69%	6	20,00%
Portfolio management	4	22,20%	11	61,10%	3	16,69%	-	-
Derivatives and futures	14	87,51%	2	12,51%	-	-	-	-
Interest	7	50,00%	3	21,45%	2	14,30%	2	14,30%
Fraud	5	83,30%	-	-	-	-	1	16,69%
Others	18	64,30%	5	17,87%	4	14,30%	1	3,59%

Source: Research data.

Table 6. Most common techniques combinations

Types	Frequency
RNA & AG	23
RNA & LN	12
LN & AG	4
RNA, LN & AG	3
Total	42

Source: Research data.

This may be because these items usually develop models to detect and explore patterns in time series - something that neural networks do very well.

Hybrid models

Isolating the articles that make use of hybrid models and checking each of the possible combinations of the three techniques of computational intelligence, addressed here, come up to the table 6.

Because there are several ways to combine neural networks with genetic algorithms, it is natural that this class of hybrid is quite significant: more than half of hybrid algorithms is found of this type, with promising results. It is possible, for example, using genetic algorithms to select the most important input variable of a neural network. This is critical for optimal performance of the RNA, as excess input variables leads to so-called "curse of dimensionality", damaging the quality of results (Hughes, 1968).

In one of the articles analyzed, a genetic algorithm selected the most relevant accounting information for predicting bankruptcy; later, using neural networks, companies were classified as being at risk of failure (distressed) or not. Thus, the rate of correct answers was 82%. Using a more recent evolutionary algorithm (particle swarm optimization) instead of genetic algorithms, the ratio rose to 87%. Without any selection of variables, the rate falls to 77% (KO; LIN, 2006).

Another possibility hybrid algorithm combining neural networks and genetic algorithms is to create networks that change their architectural parameters (number of hidden layers, for example) according to the problem. This technique has been successfully applied to the prediction of daily exchange rates (Nag; Mitra, 2002). In this case, a population of neural networks evolved through the AG, obtaining as a result a neural network with great architecture.

The results are encouraging: in the case of study of the yen and the dollar, the average absolute error of the hybrid model was 0.63; the best fixed architecture of neural network used had a 0.67 error. The Garch model, in turn, had a 0.66 error. This means that, at least in this case, the hybrid approach outperformed conventional methods. Finally, you can use genetic algorithms to combine the results of other decision-making systems - including users and experts. Thus, the algorithm can take advantage of both human knowledge and the ability of neural networks to detect patterns. This idea was used in predicting the Kopsi, the stock index in South Korea values (Kim et al., 2006). The goal was to classify the future movement of the market into four levels: bear, edged down, edged-up and bull.

It was found that because to adapt more quickly to changes in the environment, people can better predict the most rapid movements of the market (bull and bear); neural networks perform better in predicting more regular and smooth trends (edged and edged-up-down). Joining the two through a genetic algorithm was possible to obtain a top result, with 79.5% accuracy (compared to 66% of neural network and 59% of experts).

Another common type of hybrid model is one that combines neural networks with fuzzy logic. In this case, it is common to use known as neuro-fuzzy systems, in which the characteristics of a problem are represented by a high level language model - that is understandable by humans, since it is composed of rules type inference "if-then".

The task of the neural network is to find the best rules and adjust its parameters. Therefore, the difference between the neuro-fuzzy model and a conventional neural network is that while in the latter output is a value or a classification that later will be used in decision making, the first output is a fuzzy rule. Thus, it avoids a common criticism of neural networks: its lack of transparency, i.e the difficulty of understanding the means by which the neural network has reached a certain result; the synaptic weights are not easily interpreted by the end user. Therefore, neural networks are often called black boxes or black boxes (Olden; Jackson, 2002).

In one of the empirical applications analyzed, 290 credit applications were classified into two groups: good loans and bad loans. The hit rate of the hybrid model (neuro-fuzzy) was between 64.2% and 66.6%; a competitor method (MDA) managed to hit between 62.05% and 66.2%. Although the results are similar, the authors point out that the neuro-fuzzy system was able to identify more accurately the bad credit cases. With it, you can just reduce the Type I error - which is the most harmful in credit analysis (Malhotra; Malhotra, 2002).

CONCLUSION

As explained in the topic dedicated to methodological limitations, there are several previous articles to 2007. The beginning of this intellectual production is not very new, but the focus on applications of computational intelligence in Accounting and Finance continues to grow. The theoretical advances continue creating new possibilities - one example is the support vector machines, a new technique that has shown very promising results.

In this article, one can observe the predominance of studies involving Finance and neural networks. As for specific applications, it is clear that those related to financial markets are much more common; if they are considered articles related to stock exchanges, derivatives, commodities, forex, portfolio management and interest, we arrive at 164 articles, which accounts for more than half of the total of 278 articles analyzed.

Articles that tried to analyze the quality of credit through computational intelligence represented the second largest group of expression. Hybrid algorithms - despite the potentially superior performance in many cases, as demonstrated by the

empirical evidence presented in this paper - had a relatively negligible share of total analyzed studies. This may originate from the complexity inherent in the combination of two different techniques; it is possible that, with the popularity of computational intelligence methods, hybrids begin to be seen as a superior alternative to conquer the preference of students and Finance and Accounting practitioners.

Throughout this article were presented examples of articles that present empirical evidence that the computational intelligence methods may be useful in Finance and Accounting, despite its practical use still incipient; this suggests the need for the Business Area Professional stay up to date on the new theoretical developments of computational intelligence. The flexible nature of the techniques discussed here makes your possibilities are almost limitless, and certainly there are applications not yet explored for these promising ideas.

REFERENCES

Anuj,S., Prabin, K. P. (2012). A Review of Financial Accounting Fraud Detection based on Data Mining Techniques, International Journal of Computer Applications, Volume 39-No.1, PP.44-45

Agarwal, A., Davis, J. T., & Ward, T. (2001). Supporting ordinal four-state classification decisions using neural networks. Information Technology & Management, PP.1-5.

Calderon, T. G., & Cheh, J. J. (2002). A roadmap for future neural networks research in auditing & risk assessment**.** International Journal of Accounting Information Systems, PP.200-237.

Chen, J.-S., Chang, C. L., Hou, J.-L., & Lin, Y.T. (2008). Dynamic proportion portfolio insurance using genetic programming with principal component analysis. Expert Systems with Applications.

Cox, E. (1998). The fuzzy systems handbook: a practitioner's guide to building, using, & maintaining fuzzy systems AP Professional.

Fadlalla, A., Lin, C. H. (2001). An analysis of the applications of neural networks in finance. Interfaces, PP.112-122.

Faria, E. de, Albuquerque, M. P., Gonzalez, J., Cavalcante, J., & Albuquerque, M. P. (2009). Predicting the Brazilian stock market through neural networks & adaptive exponential smoothing methods. Expert Systems with Applications, PP.12505-12510.

Grint, K. (1997). Fuzzy management: contemporary ideas and practices at work. New York: Oxford.

Hwang, M. I., & Lin, J. W. (2000). Neural fuzzy systems: A tutorial and an application. The Journal of Computer Information Systems, PP:27.

Hughes, G. F. (1968). On the mean accuracy of statistical pattern recognizers**.** IEEE Transactions on Information Theory, PP.54-65.

Kim, M. J., Min, S. H., & Han, I. (2006). An evolutionary approach to the combination of multiple classifiers to predict a stock price index. Expert Systems with Applications, 31 (2): PP.240-248.

Ko, P. C., & Lin, P. C. (2006, Marco). An evolution-based approach with modularized evaluations to forecast financial distress. Knowledge-Based Systems, 19 (1): PP.83-90.

Malhotra, R., & Malhotra, D. K. (2002). Differentiating between good credits and bad credits using neuro-fuzzy systems. European Journal of Operational Research, PP.190-212.

Mochon, A., Quintana, D., Sáez, Y., & Isasi, P. (2008). Soft computing techniques applied to finance. Applied Intelligence,PP.110-116.

Montagna, Guido et al. (2003). Pricing derivatives by path integral and neural networks.: PP.189-196.

Muller, B., & Reinhardt, J. (1990). Neural networks: an introduction. Berlin: Springer-Verlag.

Nag, A. K., & Mitra, A. (2001). Forecasting daily foreign exchange rates using genetically optimized neural networks. Journal of Forecasting, Chichester, PP.501.

Nanda, S., & Pendharkar, P. (2001). Linear models for minimizing misclassification costs in bankruptcy prediction. International Journal of Intelligent Systems in Accounting, Finance & Management, PP.155.

Nunez-letamendia, L. (2002). Trading systems designed by genetic algorithms. Managerial Finance, Patrington, PP. 87.

O'connor, N., & Madden, M. G. (2006, September). A neural network approach to predicting stock exchange movements using external factors. Knowledge-Based Systems, 19 (5): PP.371-378.

Olden, J. D., & Jackson, D. A. (2002). Illuminating the "black box": a randomization approach for understanding variable contributions in artificial neural networks. Ecological Modelling, 154, PP.135-151.

Qi, M., & Zhang, G. P. (2001, August). An investigation of model selection criteria for neural network time series forecasting. European Journal of Operational Research, (3):PP. 666-681.

Rafaely, B., & Bennell, J. A. (2006). Optimisation of FTSE- 100 -tracker funds; A comparison of genetic algorithms and quadratic programming. Managerial Finance, Patrington, PP.477.

Streit, R. E., & Borenstein, D. (2009). An agent-based simulation model for analyzing the governance of the Brazilian Financial System. Expert Systems with Applications, PP.11489-11502.

Tang, T. C., & Chi, L. C. (2005). Predicting multilateral trade credit risk: comparisons of logit and fuzzy logic models using ROC curve analysis. Expert Systems with Applications, 28 (3): PP.547-557.

Ubeyli, E. D. (2007, November). Implementing automated diagnostic systems for breast cancer detection. Expert Systems with Applications, PP.1054-1063.

Wong, B. K., Lai, V. S., & Lam, J. (2000, September). A bibliography of neural network business applications research: 1994-1998. Computers & Operations Research, 27, PP.1045-1077.

Wong, B. K., & Selvi, Y. (1998). Neural network applications in finance: A review and analysis of literature (1990-1996). Information & Management, 34, PP. 129-140.