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Application of Ann in Australian Credit Card Approval

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Abstract. Nowadays, credit cards became popular in both developed and developing countries. For lenders, more credit card applications mean more complex decision making process. The purpose of this research was to examine how accurate and reliable results Neural Networks (ANN) can provide for Credit Card approval. Research was done using Australian Credit Card Approval Dataset which has interesting mixture of data and 690 instances. Thirty experiments were done using two and three hidden layers, and back-propagation training method. Results indicated high level of reliability and accuracy of 87 % which is good empirical evidence that ANN can be used as reliable tool for credit card approval.

Keywords: Neural networks (ANN), bank, credit card, accuracy.

Introduction

In the era of capitalism, efforts to include disadvantaged in the process of entrepreneurship and to decrease the gap between poor and rich people resulted in demand for loans and credit cards. Because of globalization, even in the developing countries, use of credit cards became reality. This is opportunity for clients, but on the other side, threat for lenders who are faced with more complex problem of credit approval. According to Sum Sakprasat& Mark C. Sinclair (2007), this is particularly true in situations, such as developing countries, where established guidelines and models from developed countries may not be reliably applied. Therefore they stated that there is a need for automatic credit approval that can assist credit professionals in assessing consumer credit applications (Sakprasat&Sinclair, 2007).

Twelve years back, Kate A. Smith &Jatinder N.D. Gupta (2000) stated that neural networks are becoming increasingly popular in business and that many organisations are investing in neural network and data mining solutions to problems which have traditionally fallen under the responsibility of operations research. In fact, over the last two decades, because of complexity that business is being faced with, especially international businesses, and because of rapidly changing environment, managers are trying to find additional tools to make better decisions. Therefore, technologies such are neural networks; data mining methodologies are becoming increasingly popular. They are being used for various tasks, but main are forecasting, modelling, clustering and classification. It is important to say that for many years, banks used credit scoring techniques to determine which loan applicants they should lend money to (Smith& Gupta, 2000).

This paper is trying to find out up to which level of accuracy, Analytical Neural Networks can be used as reliable tool for processing credit card applications and making the right decision.

Literature review

As technological development and its application in banking sector are quite well covered by the literature, it is possible to state that there were no difficulties while searching for adequate references regarding this research. Literature used in this work is mixture of journal articles (mainly), conference proceedings, one book and website.

In 1992, Herbert Jensen wrote an article that presents utilization of ANN in credit scoring using personal DOS computer. Logic of classification customers into groups enables decision maker to make right decision about providing of loan. Main reason for considering this article in literature review is fact that same logic was applied in this research. Difference is only of formal character. While in 1992, personal DOS computer was used to conduct credit scoring, nowadays with powerful personal computers and Mat-Lab; credit scoring can be done much faster and with much more variables involved (Jensen, 1992).

One year later, in 1993, Mohammed H.A. Tafti and EhsanNikbakht were writing about NN as new horizon in business finance applications. In this work, authors explained that NN involve an emerging artificial intelligence (AI) technology which simulates the human brain on the computer. This enablesanalysing problems considering many variables. Main characteristic of NN is ability to learn, similar to human learning process. In next section of his work, Tafti and Nikbakht (1993) mentioned that NN is widely used in making financial decisions, and as one of the examples they mentioned credit scoring. Using NN for credit scoring is actually utilizing a model or method of evaluating a set of variables to determine creditworthiness of the personal or commercial loan applicants. The model takes the value of each variable and calculates a combined credit score (Tafti&Nikbakht, 1993).

Before writing our article, since area of both authors is Management, it was very important to find a resource that will provide basic insights into ANN and its applications in business. Smith & Gupta (2002) wrote book which exactly matched our need, and provided all information necessary to understand the issue of ANN as business tool. After introducing ANN, authors in this book explained its application in all segments of business such are: Retail Sales and Marketing, Modeling Premium Price Sensitivity of Automobile Insurance Customer, Identification of High-Value Customers for a Large Retail Store in Japan, Segmentation of the Portuguese Clients, Target Selection in Direct Marketing, Prediction of Survival and Attrition of Click-and-Mortar Corporations, Corporate Strategy and Wealth Creation, Credit Rating Classification, Credit Scoring Using Supervised and Unsupervised Neural Networks, Predicting Automobile Insurance Losses, Technical Forecasting of Foreign Exchange Rates, Using Neural Networks to Discover Patterns in International Equity Markets, Cash Flow Forecasting. After going through this book, chapter 10 (which deals with credit scoring) was selected as area of our research (Smith & Gupta, 2002).

Motivated with businesses' high level of utilizing and relying upon intelligent solutions such are NN and genetic algorithms (GA), Metaxiotis and Psarras (2004) wrote an article which provides overview for the operations researcher of the neural networks and genetic algorithms methodology, as well as their historical and current use in business. Their aim was actually to present NN and GA's applications in businesses recorded by the literature. In the end, authors concluded that literature provided many empirical evidences that both NN and GA provide practical benefits to organizations (Metaxiotis and Psarras, 2004).

Sum Sakprasat and Mark C. Sinclair (2007) investigated Australian Credit Card Approval data set using eight different genetic programming (GP) approaches for the classification. Overall accuracy level of their results was 83 percent. It is important to state that our research was using the same dataset, and investigating same issue but through application of NN instead of GP. Since result of our research indicated accuracy level of 87 percent, it is possible to conclude that NN till now proved to be more accurate than GP (Sakprasat and Mark C. Sinclair, 2007).

Considering ANN as an inductive algorithm in discovering predictive knowledge structures in financial data and used to explain previous bank failures in the Turkish banking sector, Gunay and Ozkan (2007) aimed to propose a new technique to prevent future crises, with reference to the last banking crises in Turkey. Authors concluded that ANN can be very useful to predict patterns, trends in financial data, and therefore it can be utilized as powerful tool to predict potential failures and signalize possibility of making mistake long time before it happens. This is one more article

that supported statement about high level of practical benefits of ANN application by banks (Gunay&Ozkan, 2007).

Nabil El-Sawalhi, David Eaton and RifatRustom (2008) wrote paper with purpose to introduce an evolved hybrid genetic algorithm and neural network (GNN) model. Authors developed model to predict contractor performance given the current attributes in a process to pre-qualify the most appropriate contractor. In the end, results indicated that there is a satisfactory relationship between the contractor attributes and the corresponding performance in terms of contractor's deviation from the client objectives. Model accuracy was 85 percent (El-Sawalhi, Eaton, Rustom, 2008).

Abdou (2009) investigated efficiency and effectiveness of alternative credit-scoring models for consumer loans in the banking sector through testing data set of 630 loan applications. Investigation was conducted into both neural nets (NNs), such as probabilistic and multi-layer feed-forward neural nets, and conventional techniques, such as the weight of evidence measure, discriminant analysis and logistic regression. NNs gave better average correct classification rates (Abdou, 2009).

Marina Dobrota, NemanjaMilenković, VeljkoJeremić, AleksandarĐoković (n.d.) used NN to classify countries according to the level of economic development, in terms of measuring income in these countries. Results indicated that the classification accuracy is over 87%, and that GDP per capita, food supply and GDP per employee are factors proven to be the main indicators of the level of countries' economic development in terms of measuring income in these countries (Dobrota, Milenković, Jeremić, Đoković, n.d.).

Literature review is summarized in Table 1 presented below.

Table 1. Summary of Literature Review

Authors	Year	Title	Literature review
Herbert L. Jensen	1992	Using Neural Networks for Credit Scoring	Utilizazion of ANN in credit scoring using personal DOS computer in far 1992.
Mohammed H.A. Tafti and Ehsan Nikbakht	1993	Neural Networks and Expert Systems: New Horizons in Business Finance Applications	Neural Networks (NN) was percieved as new horizont in business finance applications.
Kate A. Smith, Jatinder N. D. Gupta	2002	Neural Networks in Business: Techniques and Applications	After introducing ANN, authors in this book explained its application in all segments of business.
Kostas Metaxiotis, John Psarras	2004	The contribution of neural networks and genetic algorithms to business decision support	Authors concluded that literature provided many empirical evidences that both NN and GA provide practical benefits to organizations.
Sum Sakprasat, Mark C. Sinclair	2007	Classification Rule Mining for Automatic Credit Approval using Genetic Programming	Authors investigated Australian Credit Card Approval data set using eight different genetic programming (GP) approaches for the classification. It is same dataset used in our research. Since result of our research indicated accuracy level of 87 percent, it is possible to conclude that NN till now proved to be more accurate than GP which was 83 percent.

E. NurOzkan-Gunay and Mehmed Ozkan	2007	Prediction of bank failures in emerging financial markets: an ANN approach	Authors concluded that ANN can be very useful to predict patterns, trends in financial data, and therefore it can be utilized as powerful tool to predict potential failures and signalize possibility of making mistake long time before it happens.
Nabil El-Sawalhi, David Eaton, Rifat Rustom	2008	Forecasting contractor performance using a neural network and genetic algorithm in a pre-qualification model	Results indicated that there is a satisfactory relationship between the contractor attributes and the corresponding performance in terms of contractor's deviation from the client objectives. Model accuracy was 85 percent.
Hussein A. Abdou	2009	An evaluation of alternative scoring models in private banking	After many evaluations of various alternatives, NNs gave better average correct classification rates.
Marina Dobrota, Nemanja Milenković, Veljko Jeremić, Aleksandar Đoković	n.d.	Neural Networks in determining the level of countries' economic development	Results indicated that the classification accuracy is over 87%, and that GDP per capita, food supply and GDP per employee are factors proven to be the main indicators of the level of countries' economic development in terms of measuring income in these countries.

Problem definition

In order to explain the problem, it is important to define two important terms, credit risk and credit scoring. According to Kah Hwa Ng (1996), credit risk is defined as risk of loss to lenders due to customers defaulting on their credit obligations because of unwillingness, inability, bankruptcy or any number of other reasons why the customers cannot repay the credit. Liu, (2001) says that credit scoring refers to evaluation system created to improve lender's abilities in determining the credit risk of client in process of risk analysis.

In most cases, empirical testing of credit risk is based on analysing past client's credit data using appropriate algorithms. This is powerful step to know more about client and his ability to handle the credit. In order to see how Artificial Neural Networks can contribute to solving mentioned problem, it was decided to use Mat-lab to test dataset named Australian credit card approval. The main question to answer is actually how to select appropriate clients for approving credit cards with minimum possible error.

Australian credit card approval, Data set

Australian credit card approval is dataset consisted of data about credit card applications. All attribute information is changed to meaningless symbols in order to protect privacy of customers and confidentiality of data. Also, dataset is consisted of attributes that are continuous, nominal with small number of values, and nominal with large number of values. Original source of dataset is highly protected, and it is submitted by quinlan@cs.su.oz.au. Dataset has fourteen attributes, six of which are continuous and eight categorical.

A1: 0,1 CATEGORICAL a,b
A2: continuous.
A3: continuous.
A4: 1,2,3 CATEGORICAL p,g,gg
A5: 1, 2,3,4,5, 6,7,8,9,10,11,12,13,14 CATEGORICAL ff,d,i,k,j,aa,m,c,w, e, q, r,cc, x
A6: 1, 2,3, 4,5,6,7,8,9 CATEGORICAL ff,dd,j,bb,v,n,o,h,z
A7: continuous.
A8: 1, 0 CATEGORICAL t, f.
A9: 1, 0 CATEGORICAL t, f.

A10: continuous.
A11: 1, 0 CATEGORICAL t, f.
A12: 1, 2, 3 CATEGORICAL s, g, p
A13: continuous.
A14: Class - Class 0 - Class 1 continuous

Number of instances in this data set is 690. Also, it is important to ad that in the dataset, there were missing values in 37 cases which is 5 %. There were one or more missing values in those cases. Those missing values were:

A1: 12
A2: 12
A4: 6
A5: 6
A6: 9
A7: 9
A14: 13

These cases were replaced by the mode of the attribute when it comes to categorical dataand by the mean of the attribute in a case of continuous data.

Methodology

Mat-lab 7.12.0.has been usedfor conducting all experiments.In order to find out how accurate results lenders can get using Neural Networks in their decision making about credit approval, back-propagation method of training artificial neural networks was utilized(Figure 1).Through back propagating the errors, network learns from many inputs that come from desired output.

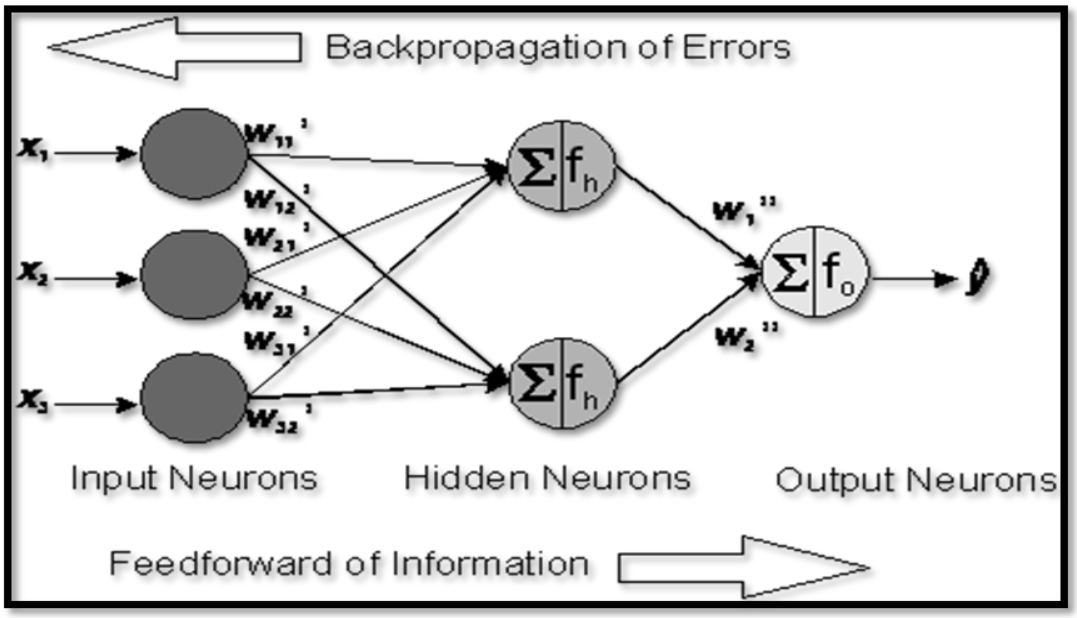

Figure 1. Feed-forward back-propagation network architecture

Architecture of neural network is based on MLP (Multi-Layer Perceptron) network. In order to get most accurate results, in this study it is conducted 30 experiments. Twenty five of them were conducted using architecture consisted of two hidden layers, while five is done using three hidden layers.Also, twenty is done using “trainlm” algorithm of learning, while ten is conducted using “traingd” algorithm of learning. Value of “Epoch” was changing many times accordingly.

When experimenting with two hidden layers, I used “logsig”, “tansig” for first and second hidden layer, and “purelin” function for output layer. During experiments with three hidden layers, “logsig”, “tansig” and “tansig” were functions used for three hidden layers, while “purelin” function was used for output layer (Figure 2).

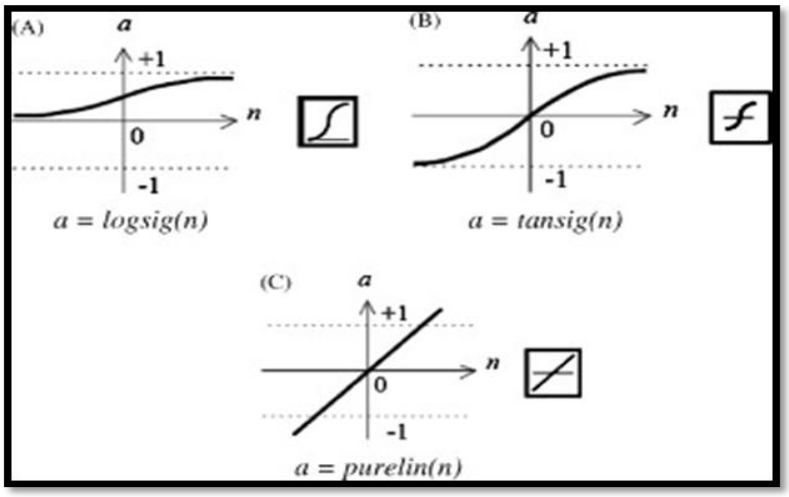

Figure 2. Activation functions used in experiments

Experiments and results

As it was previously mentioned, experiments were done using two and three hidden layers in the neural network architecture, and by using "trainlm" and "traingd" learning algorithms. Experiments and their results will be presented in two tables (Table 2 & Table 3) below. Table 2 presents experiments conducted using three hidden layers architecture of network.

Table 2. Experiments & results using three hidden layers

#	I hidden layer	II hidden layer	III hidden layer	Output layer	Trans Func.	Learning algoryth m	Epoch	Tim e	Accurac y %
1	30	10	5	1	Logsig-tansig-tansig-purelin	trainlm	450	4	83
2	40	30	10	1	Logsig-tansig-tansig-purelin	trainlm	250	21	85
3	37	25	15	1	Logsig-tansig-tansig-purelin	trainlm	500	15	83
4	57	30	20	1	Logsig-tansig-tansig-purelin	trainlm	300	82	80
5	50	40	30	1	Logsig-tansig-tansig-purelin	trainlm	500	135	85

Totally, five experiments have been done using three hidden layers, and from table 2 it is possible to conclude that accuracy levels achieved using "trainlm" learning algorithm and "logsig" "tansig" "tansig" "purelin" as trans. functions are not extraordinary since highest accuracy level was not more than 85 %. Nevertheless, results show level of accuracy that can be reliable tool for lender to use when deciding about credit approval.

Table 3. Results of experiments done using two hidden layers

#	I hidden layer	II hidden layer	Output layer	Trans Func.	Learning algorythm	Epoch	Time	Accuracy %
1	20	15	1	Logsig-tansig-Purelin	trainlm	336	3	84
2	20	10	1	Logsig-tansig-Purelin	trainlm	570	3	82
3	30	10	1	Logsig-tansig-Purelin	trainlm	634	10	87
4	57	20	1	Logsig-tansig-Purelin	trainlm	767	15	84
5	120	30	1	Logsig-tansig-Purelin	trainlm	500	226	77
6	10	5	1	Logsig-tansig-Purelin	trainlm	336	10	87
7	20	10	1	Logsig-tansig-Purelin	trainlm	400	2	79
8	30	10	1	Logsig-tansig-Purelin	trainlm	300	7	80
9	57	30	1	Logsig-tansig-Purelin	trainlm	767	40	75
10	67	37	1	Logsig-tansig-Purelin	trainlm	500	62	83
11	20	10	1	Logsig-tansig-Purelin	trainlm	500	15	85
12	10	5	1	Logsig-tansig-Purelin	trainlm	300	4	78
13	30	20	1	Logsig-tansig-Purelin	trainlm	700	7	83
14	57	30	1	Logsig-tansig-Purelin	trainlm	500	29	83
15	70	57	1	Logsig-tansig-Purelin	trainlm	350	165	80
16	20	10	1	Logsig-tansig-Purelin	traingd	500	7	85
17	10	5	1	Logsig-tansig-Purelin	traingd	570	24	84
18	30	20	1	Logsig-tansig-Purelin	traingd	634	6	82
19	57	30	1	Logsig-tansig-Purelin	traingd	767	15	84
20	70	57	1	Logsig-tansig-Purelin	traingd	500	13	79
21	10	5	1	Logsig-tansig-Purelin	traingd	336	7	66
22	20	10	1	Logsig-tansig-Purelin	traingd	400	5	83
23	30	10	1	Logsig-tansig-Purelin	traingd	300	4	85
24	55	25	1	Logsig-tansig-Purelin	traingd	333	6	85
25	100	40	1	Logsig-tansig-Purelin	traingd	500	13	86

Level of variance among results is not high. Accuracy levels calculated using two hidden layers are values between 75 % and 87 % which means that most of the results are quite reliable. However, the biggest level of accuracy occurred in third experiment. Accuracy level that is achieved using 30 neurons in first and 10 neurons in second hidden layer proved as best result since it achieved maximum accuracy value of 87 %. Mean Squared Error in this case was 0,1305.This supports statement that Artificial Neural Networks can be used as highly accurate and reliable tool for lenders' decision making process. Additionally, mentioned highest result was achieved using "logsig" "tansig" "purelin" activation functions, "trainlm" learning algorithm and the best training performance occurred at634th epoch. Mat-lab did calculation in not more than ten seconds of time (Figure 3).

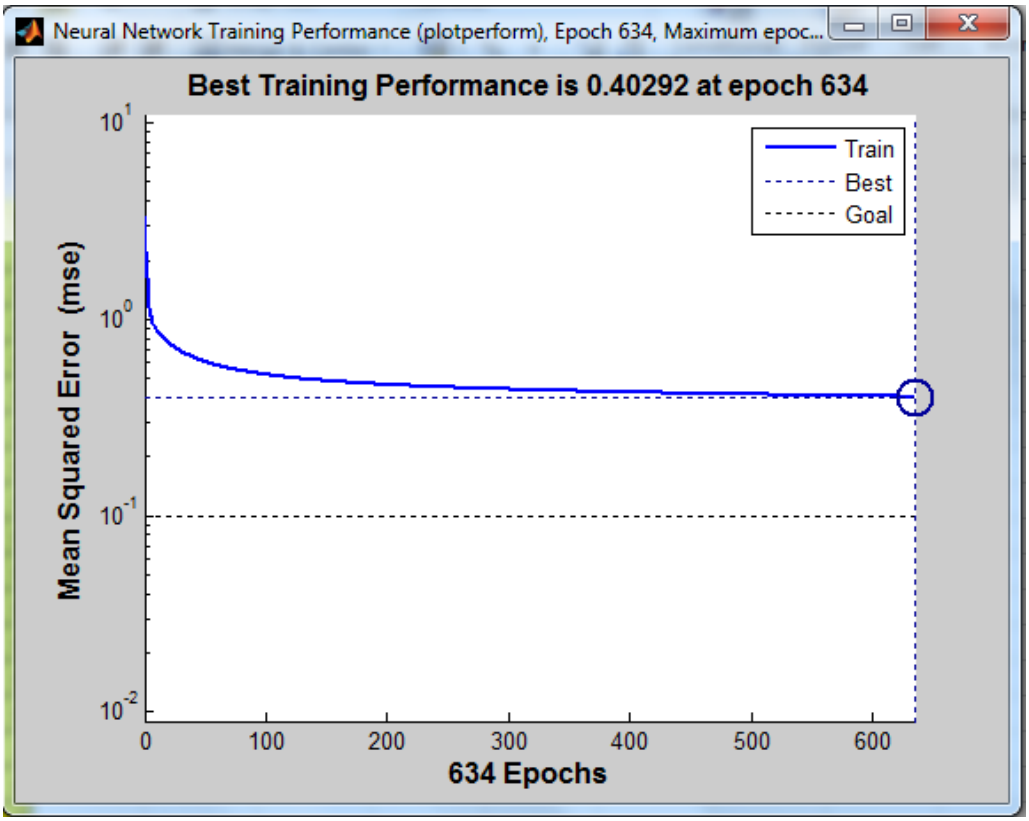

Figure 3. Plot of Best Training Performance

Comparison with other approaches

Overall aim of this research was to find out accuracy level of Neural Networks application in Australian Credit Card Approval. Comparison of this paper's results with results that are achieved through experiments on the same data set but using other approaches shows that results achieved in this study are highly successful and confidential. Results of this study were actually compared with the quality of the best algorithms from Statlog (Statlog datasets: comparison of results) and found that result achieved in this paper are better compared to best results found at Statlog. Best result of minimum error at Statlog is 0, 1310 and minimum error mentioned below in this study is 0, 1305.This comparison makes this study more valuable and proves that Neural Networks should definitely be considered as important tool for automatic credit scoring.

Research limitations

Since in the output layer there was only one neuron which means that result is categorical to 1 or 0 ("yes" or "no"), analysis conducted by Mat-lab in this paper can provide only two groups of clients (credit card applicants). "Yes" refers to group of people whose credit risk is small enough to get credit approval, and "no" reflects applicants with high credit risk so they cannot get credit approval.However, in reality there are always groups of applicants that require deeper analysis because they are somewhere in the middle between mentioned groups. Therefore, they require special attention, and one of the limitations of this research is fact that it gives only "good" and "bad" credit applicants. If research could be conducted in a ways that beside "good" and "bad"

applicants, system offers also "intermediate" ones, it would be more useful since credit lenders would be able to know who among applicants require more attention when deciding.

Conclusion

Nowadays, credit cards became popular not only in developed, but even in developing countries. On the other side, credit lenders are faced with more and more credit applications. This study aimed to learn how accurate result, ANN can provide for Credit Card approval. Research was done using Australian Credit Card Approval Dataset that is big enough and full of data types which is making it more interesting. Experiments were done using two and three hidden layers, and using back-propagation training method supported by using "trainlm" and "traingd" learning algorithms. Best result occurred in an experiment with twenty neurons in first, and ten neurons in second hidden layer at 634th epoch, and its accuracy was 87 %. Compared to results of other approaches, this is very valuable and good accuracy that proves that ANN can be used as reliable tool for credit card approval.

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