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A Genetic Algorithm for predictive Neural Network Design (GANND).
A Financial Application

by

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Summary

In this preliminary work on the application of Hybrid Algorithms to Financial Forecasting (HAF[2]) we show a computational approach integrating Artificial Neural Networks (ANN) and Genetic Algorithms (Gas) facing the problem of building the optimal model in a multivariate non-linear environment. This is the typical environment in financial and economical time series where the number of variables influencing a given phenomena is really high and moreover the functional relations linking them are not a-priori known.
Because of their high flexibility Artificial Neural Networks (ANNs) have been widely used to build non linear regression models. However, the problem to build the best ANN is still open as well as the related problem of the best set of variables to be selected as regressors.
In this paper we propose an hybrid algorithm (GANND, A Genetic Algorithm for Neural Network Design) integrating Genetic Algorithms and ANN to automatically build an efficient predictive non linear model starting by the empirical data set. We also show some experimental results obtained by applying GANND to predict an Italian financial bond (FIB30).
Keywords: *Artificial Neural Networks, Genetic Algorithms, Artificial Intelligence, Financial Forecasting, Hybrid Algorithms[1].*

1 Introduction

Genetic Algorithms (GA) represent a stochastic global optimization tool emulating the genetic evolution of a biological population. They can be used to obtain near-optimal solution in multivariable problems without requiring the usual analytical regularity (continuity, differentiability, convexity, etc..) of the functions involved (Holland 1975 and 1995, Mitchell 1996, Goldberg 1989).

The GA starts by choosing an initial set of candidate solutions, the population, which propagate themselves to the next generations through a "selection criteria". Each solution, "individual", is evaluated to establish a fitness value respect to the problem under investigation. A specific class of genetic operators (selection, mutation, crossover, cloning) are applied to the population to obtain the evolution to the next generation. The genetic operators are sensitive to the Fitness Value so that to the fittest individuals will be assigned a higher selection probability. The evolution ends when the population converge to the best solution matching a preimposed stop criteria.

An Artificial Neural Network (ANN) is composed by a multilayer of processing units, *neurons*. In the Feed-Forward scheme each neuron receives information from the previous layer, processes the information performing a weighted sum of the inputs, uses the resulting sum as argument of a non-linear activation function and transfer the result (OUTPUT) to the next layer neurons. In the Recursive/FeedBack scheme the information can also follow the backward direction. For a given network topology the ANNs can learn from examples of input-output vectors how processing the input information to obtain an output answer by training their weights vector to minimize a loss function (usually the quadratic error function) (see for example Hagan 1996 and Elman 1990).

However if a researcher chose to use ANNs to perform either an adaptive or a predictive analysis on a specific problem his/her work involves not only model building and validation of such models but also the Neural Network Design. The researcher has to choose the kind of Network to use, the topology of the network (i.e.: number of layers, number of neurons in each layer, activation function from a layer to the next), the learning parameters (i.e. training algorithms, learning rate) and mainly the relevant information (the "active" information) to be presented to the network (i.e. how many inputs and which ones). Usually the network designing phase can take several working days (and maybe weeks) of an expert researcher in a typical trail-and-error scheme.

In this paper we address the problem to build a tool able to perform the Neural Network Design in a predictive environment. We propose an hybrid technology integrating Genetic Algorithms and Neural Networks (GANND: A Genetic Algorithm for Neural Network Design) that automatically, firstly, designs the best predictive Neural Network starting from the input/output data sets and then uses the designed network to perform the predictive analysis (Chatterjiee 1996, Guo 1992, Minerva 1998, Paterlini 1998).

In particular, starting from the target variable (i.e. the variable to be predicted) and from a set of candidate regressors GANND builds the predictive model by

establishing the subset (cardinality and elements) of the "active" regressors. Contemporarely GANND selects the network topology and the training scheme choosing from a set composed by more than 10^{14} possible combinations and then perform the neural network training, in a predictive environment, to obtain the best weights and biases for the selected topology and respect to the related loss function. In time series analysis the selected ANN and the optimized weights and biases are then used to obtain a prediction on future values starting from the past knowledge.
In the section 2 we illustrate the theoretical framework. In section 3 we show the GA codification and the computational details while in section 4 we discuss the experimental results based on a simulated (ex-ante) 5 months trading driven by the GANND predictions.

2_ Theoretical Framework

In the last several years there has been a great interest for computational methods designed to solve search and optimization problems. Searching the solution in a huge multimodal landscape, discovering the optimum when non-additive interactions develop among the process component, or finding formal explanation when uncertainty and instability of the performance mark the process components, are examples of problems where the computational approach has been adopted.
Evolutionary computation, in particular, has merged in this field as one of the most effective and robust tool. This approach developed with the idea that evolution of natural systems could be reproduced in a computer to evolve artificial systems. Evolution is an adaptive process since involves a progressive modification of the system components in a changing environment and, also, is a parallel process because many different possibilities are explored simultaneously in an efficient way. Moreover changes are stochastic and ruled by a set of operators. The idea of studying evolution to build computational procedures for solving problems has been introduced In particular by Box (1957) and Friedman (1959) but developed and implemented by Holland (1975, 1995) and later by Goldberg (1989), Mitchell (1996) and Fogel (1996).
An artificial adaptive system is usually represented by the following set of elements:

$$\{A, I, \Omega, \tau\}$$

where:
$A = \{A_1, A_2, ...\}$ represents a collection of possible structure of the system;
I is a set of inputs that the system receives from a chosen environment;
$\Omega = \{\omega_1, \omega_2, ...\}$ is a set of operators which modify the structure A element of A;
τ is an adaptive plan describing the changes in the system.

In this artificial world the possible structures of the system are assumed to be the potential solutions of the problem. Usually they are numerous and high quality. In tackling a problem they compete and their performance can be evaluated.

In the field of evolutionary computation Genetic Algorithms represent step-by-step procedures designed to evolve artificial systems toward the best computational solution. Details on Genetic Algorithms and Genetic Programming can be found in Davis (1991), Mitchell (1996), Holland (1975 and 1996), Goldberg (1989) and Koza (1996).
Suppose now we have a set of statistical variables **Y** and **X**=$X_1....X_k$ with N observations each. Y is the response variable and X is a set of possible regressors for **Y**. The relation between **Y** and **X** can be represented by the following statistical model:

$$Y = g(\Omega;\Theta) + \varepsilon$$

where Ω is a subset of **X**, g is a function identifying the model class, Θ is a set of parameters identifying the several members in the g-model class and ε is the usual stochastic white noise. In many cases one has enough information to select (or hypothesize) the model class (linear, polynomial, exponential, logistic, etc...) and the main effort has to be devoted to select the subset Ω of effective regressive/predictive variables to be used. Parameters estimation can be performed with classical analytical techniques or by the usual numerical optimization algorithms. If g has supposed to be linear respect to the parameter, set different selection tools are available to drive the search of the optimal Ω set (stepwise regression, factorial analysis, partial and inverse correlation matrix, etc...). In more complex (and realistic) problems g is far to be linear and often is also far to be a-priori known. This is the case of financial time-series where the influencing factors, their relevance and their mutual interactions are not know and one can only guess that autoregressive as well as exogenous variables can have some influence on the behaviour of the investigated phenomena.
In this framework one has to be able to establish an appropriate class of models, **G**, to select the best model, g, in **G** by setting up the best subset of regressors, $\Omega(g)$, and to evaluate the fittest parameter values, $\theta(g,\Omega)$. Note that Ω is function of g and θ is function of g and Ω.
A further complication arises from the correct chose of the loss function to be used to test the goodness of the designed model. The usual quadratic loss (or the previsional Akaike's AIC criterion) seems to be a very poor indicator in problems related to financial forecasting where the operator is not really interested in minimizing the square root error but in maximizing the trading gain! In Paterlini (1998) and Minerva (1998) we have already shown that choosing the correct gain function (loss function) is not so obvious and is the cornerstone on which one has to develop the model analysis.
Because we were mainly interested to perform financial analysis and forecasting, we called the gain function Trading Strategy Gain (S). The goal was then to learn from past data how to build a model able to maximize the Trading Strategy Gain. So all the parameters in the model has to set up to the Trading Strategy Gain, **S**. The trading gain is not a loss function in the sense that it can assume both negative and positive values and the fitness value has to be established balancing trading losses and gains. We'll call it gain index, GI_S, labelled by S (Strategy) because it is related to a well established trading strategy.

In more formal terms he problem can be so summarized:

X=$X_1,....X_k$ is the set of know variables.
Y is the variable to be predicted.
$\mathbf{GI_S}$ is the loss (gain) index to be used as Fitness Function.
$\mathbf{M_S}$ $(G, \Omega;\Theta)$ represents the model space once we established S. Ω defines the set of subsets of X to be used in the G set of model functions. Θ is the set of possible parameters.

The goal is to found the model able to maximizing the gain index, GI_S, by selecting the appropriate model components:

1. g from a given a set G of functions
2. $\omega=\{\omega_1....\omega_p\}$ where $\omega_i = X_j$ for some j.
3. $\theta = \{\theta_1,..,\theta_q\}$ the set of parameters to be used.
   and, finally, by estimating the value of θ.

ANNs can be revised as universal approximation tools because of their high flexibility and adaptability so we chose a set of ANNs as model functions set, **G**, for our model building problem.
But the task to establish the right ANN for the investigated data is really hard. Infact one as to chose several ingredients: Input Scheme (i.e. how many and which ones variables and how one should present them to the network: serial, parallel, batch), Number of Layers, Neurons in each layer, Transfer Functions between two close layers, Training and Optimization Algorithms, Learning Parameters and the Convergence Criterion.
The problem of choosing the best ANN can be regarded as the one to select the best combination of ANN components in the sense that best means the combination that minimize the loss function.
A search algorithm could, then, be used to select the optimal ANN/model (Guo 1992, Chatterjee 1996, Minerva 1998). In this paper we address this problem by using an evolutionary global search algorithm: Genetic Algorithms. In the GAs scheme a 'chromosome' coding the corresponding ANN will represent each potential solution. A set of solutions ('population') will be evolved by a set of genetic operators through several runs, 'generations', toward the best fitting individual. The individuals will be evaluated by the Fitness Value (in our case the Gain Index) representing their closeness to the best performance. In practical terms a GA search needs these steps:

1. The Problem Coding: how one has to build the chromosome to represent a correct solution.
2. The evolutionary scheme: the genetic operators, the selection and the transition rules through the generations.
3. The convergence criteria.
4. The Fitness Function to evaluate the Fitness Value for a given individual. The Fitness Value will establish the selection and transition probabilities.

Details on this four important points can be found in Mitchell (1996), Goldberg (1989) and Holland (1975 and 1996) and therein. In the next session we show how we implemented a Genetic Code to search the optimal ANN from a large set (more than 10^{14}) of possible solutions in a predictive problem related to financial time series.

Genes : 1-32 Delays	Close Price Delays (from x_t to x_{t-31})
Genes : 33–46 Market Indexes and Technical Indicator	Comit index Mib index Mib30 index Mibtel index Fib 30 Minimum Price Fib 30 Maximum Price Fib 30 Open Price 3 days Moving average 5 days Moving average 10 days Moving average 15 days Moving average 20 days Moving average 5 days Relative Strenght Index 10 days Relative Strength Index

Table I: Structure of the first part of each chromosome of GA.

3 Genetic Code and Computational Details

The Genetic string is a mixed binary and real values code representing the ANN ingredients. The Chromosome, composed by 58 genes, can be divided into 2 main parts: the first one (46 genes) has been devoted to select the input variables while the second (12 genes) represents the topological structure of the ANN (neurons, transfer functions, learning rate, training scheme). This division is only conceptual; the search was globally performed on the whole chromosome.

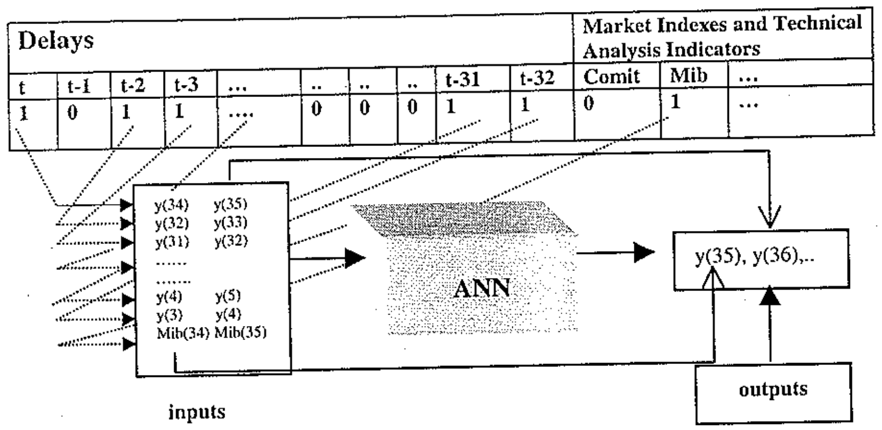

Figure 1: Gannd structure (first part- variable selection).

The first part is a binary code whose length is the number of regressive (and autoregressive) variables we are using. Each gene represents a variable. If the gene value is zero this means we must not include that variable in the input set for the ANN. While if the gene value is one we must include the corresponding variable. Because our goal was to make prediction on a financial bond (The Italian Future Bond FIB30) we considered as set of possible variables 32 autoregressive variables (to predict the y(t+1) value we included delay from y(t) to y(t-31)) and 14 technical analysis indices and market indicators coming from the market analysis at the time t, so the first part of the chromosome is 46 genes long, each gene representing one of the 46 variables (see Table I). An example has been shown in Fig. 1 where a genetic code has been set up to select the variables to be used to predict the values of y(35) and y(36).

The second part of the chromosome is a real-to-binary code of the ANN topology. By example, the genes 47-51 coded the number of neurons in the hidden layer, since they can code 32 different binary values we associated this string to the real values from 1 to 32 and so on for the other elements of the ANN (see table II for the complete genome).

Genes : 1-32 Delays	Close Price Delays (from y_t to y_{t-31})
Genes : 33-46 Market Indexes and Technical Indicator	Comit $index_t$ Mib index Mib30 index Mibtel $index_t$ Minimum Price $Fib30_t$ Maximum Price Fib30 Open Price $Fib30_t$ Moving average 3 $days_t$ Moving average 5 $days_t$ Moving average 10 $days_t$ Moving average 15 $days_t$ Moving average 20 $days_t$ Relative Strenght Index 5 $days_t$ Relative Strength Index 10 $days_t$
Genes 47-51: Number of Neurons in the hidden layer	From 1 to 32
Genes 52-53: Transfer Function	1. Linear 2. Log-sigmoid 3. Tan-sigmoid 4. Linear
Genes 54-56: Value of Learning Rate	From 10^{-1} to 10^{-8}
Genes 57-58: Training procedure	1. Elman Network 2. Feed Forward with Back-Propagation 3. Adaptive Network 4. Radial Basis Network

Table II: Complete GANND chromosome structure.

Using this schema we applied GANND to select the optimal ANN to perform the best prediction on the FIB30 price at $t+1$ knowing the price series from t to $t-32$ and the set of indices at t. The previsional analysis was performed on a set of 1000 experimental data corresponding to about 4 trading years divided into the usual randomly disjoint training (500 days), validation (250 days) and test (250 days) sets.
The AIC information criterion was used as a preliminary fitness function to establish the fitness value of a given individual in order to select the predictive model and the network topology and the three disjoint data sets (training, validation and test) were used to perform the model training, validation and test.

4 Experimental

As first step we tested GANND on a large class of simulated time series with and without gaussian white noise. We evaluate GANND on Reduced Fourier Series with order going from 10 to 100 terms and with an added stochastic white noise with maximum amplitude, respect to the deterministic input, going from 0 (no noise) to 80%. In this case we choose to select as regressors only auto-regressive variables obtaining predictions within 5% of average errors also in the higher order series with 80% of white noise contribution (see Fig. 2).

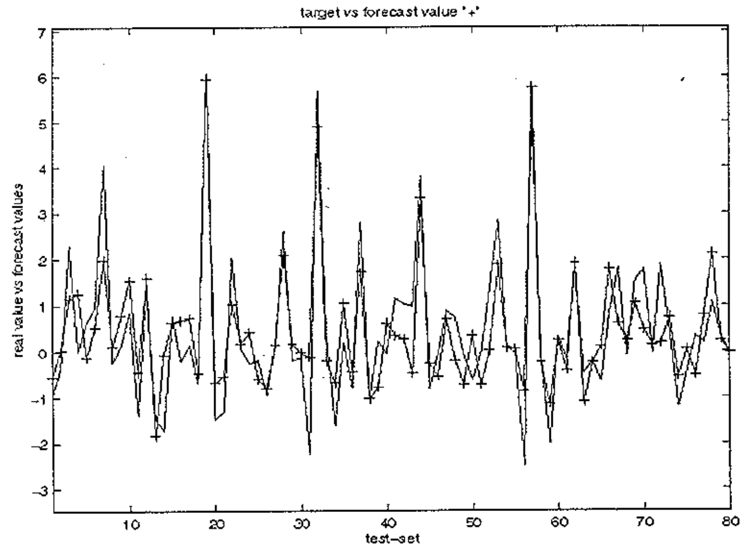

Figure 2: Forecast vs Real Value for a order 10 Reduced Fourier Series with an added stochastic white noise whose maximum amplitude is 80% respect to the deterministic signal amplitude.

As second step we used GANND and the same autoregressive scheme to perform a predictive analysis on a financial bond. In a very preliminary step we tried to predict the Close Price of the FIB30 (the future contract based on the Italian Stock Market Index, MIB30) at the time $t+1$ by knowing the Close Price time series until time t.
In this case we obtained that the best prediction for the price at $t+1$ was the price at time t. We felt into a Randow Walk of the Financial Markets that cannot be practically used by an investor (figure 3).

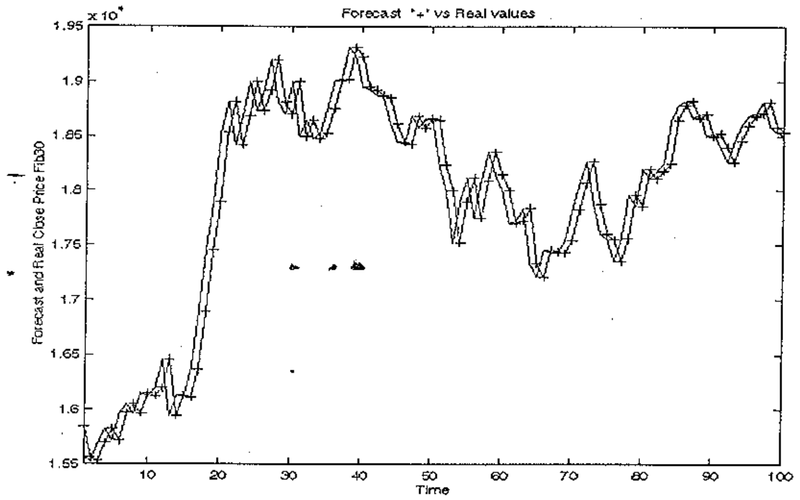

Figure 3: Forecast vs real values of Fib30 Close Price of short term contract.

Despite the prediction looks quite excellent at a first glance it is completely useless and cannot be claimed as generated by numerical approximation or imperfections but simply means that the ANN and the predictions strategy we are using are completely out of the goal. In fact this result is indicating that the best prediction for the tomorrow price is the today one!.

This is a strong evidence that something was lost in our (and similar) prediction schemas. We tried to perform a pure statistical prediction without keeping into account the real goal. In this case the real goal was to obtain from GANND an operating signal (sell/buy/neutral) optimized on a medium term real trading gain. In other words we were not interested in performing optimal predictions but in obtaining the right signal in correspondence of high gain opportunity. This means that we had to change the GA Fitness Function from AIC to a function related to a well established realistic trading strategy able to keep into full account, for a non corporate investor, the delay time from the decision to the effective investment instant, the real expenses for each operation and the risk adversion.

In this scheme the GA has to select not the ANN able to perform the best prediction but the NN able to obtain the highest gain in a medium range (3 months) of operational period. The ANN output is then not the predicted price at $t+1$ but a three-state signal [buy-sell-neutral] suggesting the investment operation at $t+1$ (Galati 1998, Tenti 1997).

We used this approach to establish a trading strategy and to simulate, ex-ante, about 5 months (from May 9th to September 29th 1997) of real daily trading on the FIB30 Italian Market. The ANN selected by GANND is shown in Table 3 while the trading strategy involves a $t+1$ and a $t+2$ prediction and an operative output signal sent to the market operator at $t+1$ (see Paterlini 1998 for a detailed discussion of the trading strategy).

Order of the Equivalent Autoregressive Model	10
Delays to be considered	1 2 3 4 5 6 7 8 9 10
Market Indexes and Technical Indicators considered	[Comit,Mib,Mib30,Mibtel,P_{min}, MA(3),MA(5), MA(10),MA(15) RSI5,RSI10]
Number of Neurons to be considered	20
Transfer Function in the hidden layer	Tangent Sigmoid
Training Network Schema	Elman
Transfer Function in the Output Layer	Linear
Learning Rate Value	10^{-3}
Fitness=Loss_net/Gaintot_net	0.4092
Gaintot_net=Sum of the positive cash-flows	162.410.000
Loss_net=Sum of the negative cash-flowes	66.467.000
Total Net Gain	95.943.000
Maximum Investment	30.000.000

Table III: Structure of the Best ANN selected by GA.

In Table III it is shown that we set the initial clearing margin to 30 Mlit. The net gain obtained in the period was about 96 Mlit (more than 300% in less of 5 months) but the real gain associated with the daily prediction/trading was about 26 Mlit (more than 85% in 5 months). The FIB30, infact, increased its prices by 70 Mlit in the trading period and we correctly must not claim this gain as associated to the GANND predictions.

We should note, however, that this positive gain contains also losses related to incorrect predictions and if we were been able to give the correct buy-sell signal each day the gain could amount to more than 285Mlit.

This means that we must improve the performance of GANND in problems related to financial predictions looking for more efficient trading strategies or for more efficient fitness functions as well as we can improve GANND by design full/partial network connectivity and/or neuron-by-neuron activation functions. While from another point of view we should consider a deeper financial analysis including more technical indices and also including macro economical variables and dummy environmental variables into the variable set.

Conclusions

Artificial Neural Networks have been widely applied to perform predictive analysis on financial and economical time series because of their high flexibility. But the same flexibility constitutes a strong limitation being based on multiparameter selection in the network topology design and in the learning schema to use. Genetic Algorithms can be used as global search algorithm to span the parameters space related to the ANNs design problem in order to find the optimal solution associated to the minimization (maximization) of a well established loss (gain) function. We have implemented a tool (GANND) able to use Genetic Algorithms evolutionary search approach to design the best ANN for a predictive problem in financial time series analysis. GANND can select the input space as well as the topological and the learning parameters involved in ANN tailoring. The Fitness Function used to drive the genetic evolution of the solution space has to be very close to the problem investigated. In financial and economical environments, infact, it has to keep into full account all the trading details. This means that in predictive problems involving financial time series the Fitness Function must represent a realistic emulation of the trading problem. Infact, as we shown in this paper, a too simplicistic Fitness Function can bring toward a useless Random Walk description of the predictive financial data.

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References

G.E.P. Box (1957), Evolutionary Operation: A method for increasing industrial productivity, Journal of the Royal Statistical Society, C6, 2, pp. 81-101.

S. Chatterjee, M. Laudato, L.A. Lynch (1996), Genetic Algorithms and their statistical Application: An introduction, Computational Statistics and Data Analysis, 22, 633-651.

L.Davis (1991), Handbook of Genetic Algorithm, Van Nostrand Reinhold, New York.

J.L. Elman (1990), Finding Structure in Time, Cognitive Science, vol 14, 179-211.

L.J. Fogel, A.J. Owens, M.J. Walsh (1966), Artificial Intelligence Through Simulated Evolution, John Wiley, New York, 1966.

L. Galati (1998), IMI-SIGECO, Milano, Private Communication.

Goldberg, D.E. (1989), Genetic Algorithms in search, optimization, and machine learning, Reading, Addison-Wesley Publishing Corporation, Inc..

Z. Guo, Uhrig R.E. (1992), Using Genetic Algorithms to Select inputs for Neural Networks.

M.T. Hagan (1996), H.B. Demuth, M. Beale, Neural Network Design, PWS Publishing Company.

J.H.Holland (1975), Adaption in Natural and Artificial Systems, University of Michigan Press.

J.H. Holland (1995), Hidden Order, Reading, Addison Wesley Publishing Co.

J.R.Koza (1996), Genetic Programming, Massachusset Institute of Technology Press.

M. Mitchell (1996), An Introduction to Genetic Algorithms, Massachussets, MIT Press.

T. Minerva, I. Poli (1998), A Genetic Algorithms selection method for predictive neural nets and linear models, Working Papers Series 228, Dipartimento di Economia Politica, University of Modena.

T. Minerva, I. Poli (1998), Building an ARMA model by using a Genetic Algorithm, Working Papers Series 229, Dipartimento di Economia Politica, University of Modena.

S. Paterlini (1998), Thesis, Faculty of Economics, University of Modena.

P. Tenti (1997), Forecasting Foreign Exchange Rate Using Recurrent Neural Network, Applied Artificial Intelligence.

D.White, D.Sofge (1992), Handbook of Intelligent Control, New York, Van Nostrand Reinhold.

1. Maria Cristina Marcuzzo [1985] "Yoan Violet Robinson (1903-1983)", pp. 134
2. Sergio Lugaresi [1986] "Le imposte nelle teorie del sovrappiù", pp. 26
3. Massimo D'Angelillo e Leonardo Paggi [1986] "PCI e socialdemocrazie europee. Quale riformismo?", pp. 158
4. Gian Paolo Caselli e Gabriele Pastrello [1986] "Un suggerimento hobsoniano su terziario ed occupazione: il caso degli Stati Uniti 1960/1983", pp. 52
5. Paolo Bosi e Paolo Silvestri [1986] "La distribuzione per aree disciplinari dei fondi destinati ai Dipartimenti, Istituti e Centri dell'Università di Modena: una proposta di riforma", pp. 25
6. Marco Lippi [1986] "Aggregations and Dynamic in One-Equation Econometric Models", pp. 64
7. Paolo Silvestri [1986] "Le tasse scolastiche e universitarie nella Legge Finanziaria 1986", pp. 41
8. Mario Forni [1986] "Storie familiari e storie di proprietà. Itinerari sociali nell'agricoltura italiana del dopoguerra", pp. 165
9. Sergio Paba [1986] "Gruppi strategici e concentrazione nell'industria europea degli elettrodomestici bianchi", pp. 56
10. Nerio Naldi [1986] "L'efficienza marginale del capitale nel breve periodo", pp. 54
11. Fernando Vianello [1986] "Labour Theory of Value", pp. 31
12. Piero Ganugi [1986] "Risparmio forzato e politica monetaria negli economisti italiani tra le due guerre", pp. 40
13. Maria Cristina Marcuzzo e Annalisa Rosselli [1986] "The Theory of the Gold Standard and Ricardo's Standard Comodity", pp. 30
14. Giovanni Solinas [1986] "Mercati del lavoro locali e carriere di lavoro giovanili", pp. 66
15. Giovanni Bonifati [1986] "Saggio dell'interesse e domanda effettiva. Osservazioni sul cap. 17 della General Theory", pp. 42
16. Marina Murat [1986] "Betwin old and new classical macroeconomics: notes on Lejonhufvud's notion of full information equilibrium", pp. 20
17. Sebastiano Brusco e Giovanni Solinas [1986] "Mobilità occupazionale e disoccupazione in Emilia Romagna", pp. 48
18. Mario Forni [1986] "Aggregazione ed esogeneità", pp. 13
19. Sergio Lugaresi [1987] "Redistribuzione del reddito, consumi e occupazione", pp. 17
20. Fiorenzo Sperotto [1987] "L'immagine neopopulista di mercato debole nel primo dibattito sovietico sulla pianificazione", pp. 34
21. M. Cecilia Guerra [1987] "Benefici tributari nel regime misto per i dividendi proposto dalla commissione Sarcinelli: una nota critica", pp. 9
22. Leonardo Paggi [1987] "Contemporary Europe and Modern America: Theories of Modernity in Comparative Perspective", pp. 38
23. Fernando Vianello [1987] "A Critique of Professor Goodwin's 'Critique of Sraffa'", pp. 12
24. Fernando Vianello [1987] "Effective Demand and the Rate of Profits. Some Thoughts on Marx, Kalecki and Sraffa", pp. 41
25. Anna Maria Sala [1987] "Banche e territorio. Approccio ad un tema geografico-economico", pp. 40
26. Enzo Mingione e Giovanni Mottura [1987] "Fattori di trasformazione e nuovi profili sociali nell'agricoltura italiana: qualche elemento di discussione", pp. 36
27. Giovanna Procacci [1988] "The State and Social Control in Italy During the First World War", pp. 18
28. Massimo Matteuzzi e Annamaria Simonazzi [1988] "Il debito pubblico", pp. 62
29. Maria Cristina Marcuzzo (a cura di) [1988] "Richard F. Kahn. A discipline of Keynes", pp. 118
30. Paolo Bosi [1988] "MICROMOD. Un modello dell'economia italiana per la didattica della politica fiscale", pp. 34
31. Paolo Bosi [1988] "Indicatori della politica fiscale. Una rassegna e un confronto con l'aiuto di MICROMOD", pp. 25
32. Giovanna Procacci [1988] "Protesta popolare e agitazioni operaie in Italia 1915-1918", pp. 45
33. Margherita Russo [1988] "Distretto Industriale e servizi. Uno studio dei trasporti nella produzione e nella vendita delle piastrelle", pp. 157
34. Margherita Russo [1988] "The effect of technical change on skill requirements: an empirical analysis", pp. 28
35. Carlo Grillenzoni [1988] "Identification, estimations of multivariate transfer functions", pp. 33
36. Nerio Naldi [1988] "'Keynes' concept of capital", pp. 40
37. Andrea Ginzburg [1988] "locomotiva Italia?", pp. 30
38. Giovanni Mottura [1988] "La 'persistenza' secolare. Appunti su agricoltura contadina ed agricoltura familiare nelle società industriali", pp. 40
39. Giovanni Mottura [1988] "L'anticamera dell'esodo. I contadini italiani della 'restaurazione contrattuale' fascista alla riforma fondiaria", pp. 40
40. Leonardo Paggi [1988] "Americanismo e riformismo. La socialdemocrazia europea nell'economia mondiale aperta", pp. 120
41. Annamaria Simonazzi [1988] "Fenomeni di isteresi nella spiegazione degli alti tassi di interesse reale", pp. 44
42. Antonietta Bassetti [1989] "Analisi dell'andamento e della casualità della borsa valori", pp. 12
43. Giovanna Procacci [1989] "State coercion and worker solidarity in Italy (1915-1918): the moral and political content of social unrest", pp. 41
44. Carlo Alberto Magni [1989] "Reputazione e credibilità di una minaccia in un gioco bargaining", pp. 56
45. Giovanni Mottura [1989] "Agricoltura familiare e sistema agroalimentare in Italia", pp. 84
46. Mario Forni [1989] "Trend, Cycle and 'Fortuitous cancellation': a Note on a Paper by Nelson and Plosser", pp. 4
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