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An Intelligent Model for Stock Investment with
Buffett Strategy, Classifier System, Neural Network and Linear Programming

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ABSTRACT

"The Intelligent Model for Stock Investment with Buffett Strategy, Classifier System, Neural Network and Linear Programming" was studied for developing an intelligent model which can learn more knowledge regarding to stock investment with artificial intelligence technology. Classifier system, neural network, fundamental financial investment factors and linear programming are the fundamental components for the research. Knowledge transformation and genetic evolution capability was discussed in the article, too. Furthermore, the investment strategy developed by Warren E. Buffett[17], the great financial investment master, was the major knowledge which was practiced in the article.

For realizing more detail about learning system, a lot of topics regarding to artificial intelligence were discussed in advanced, including "A Market-Based Rule Learning System" [1], "Dynamic Trading Strategy Learning Model using Learning Classifier System" [2], "Nonlinear Index Prediction" [3], "Financial Decision Support with Hybrid Genetic and Neural Based Modeling Tool" [4] and "Fuzzy Interval methods in Investment risk Appraisal" [5].

According to the study mentioned above, the ideas to give intelligent model, especially with genetic algorithm, bring the direction for the advanced financial investment strategy and operation. Therefore, it was why a novel intelligent model with Buffett strategy, classifier system, neural network and linear programming proposed in the article.

Keywords: Classifier System, Security Investment, Buffet, Neural Network, Linear Programming

1. INTRODUCTION

In the world of financial investment, everybody is looking forward to raising the investment visibility and get profit through transparent financial investment model. However, people are confused by too many kinds of merchandize, and suffered by the high complexity with so many connections among all investors from different security and trading market. It is possible but really difficult to award the profit in the mazy trading environment.

Trading in stock market is the most popular financial investment. The shaky price in stock market brought the possible super profit. The entry barrier to involve trading in stock market is low, too. The market price and related financial information is easy to take. It is the reason why the population of involving stock market is very high in anywhere.

For providing more intelligent technology in financial investment prediction, only the research in classifier system, neural network, linear programming, and fundamental intelligent financial investment operation, but also the investment criteria developed by Warren E. Buffett [6][17][18] was adopted for the improving the intelligence of financial investment operation.

This was why the research including linear programming, neural network, classifier system, fundamental financial investment factors and Buffett investment criteria were taken in the article. The intelligent model can be constructed by integrating these methodologies. Through the developed intelligent model and related information, the most effective rules can be retrieved for supporting financial investment decision making. The fundamental factors are wisdom-base mining operations in the intelligent model. Therefore, Buffett strategy was taken for representing the knowledge of mid-term / long-term financial investment. Furthermore, in the article the knowledge will not be limited on the idea from Buffett Strategy, but also including any financial knowledge if they will be useful for predicting the stock price in the changeable world.

2. RELATED WORK

2.1 Linear Programming

The Linear Programming (LP) [7] is the model which represents the objective system functions and related behavior. The basic definition of LP can be described as below:

Object function: minimize cx …(1)
Subject to Ax = b ……...……...(2)
x >= 0 ……………………..……..(3)

Where **x** is the multi-dimensional variable vector associated with coefficient matrix **A**, **c** 、 **b** are coefficient vectors, the formula **(2)** and **(3)** are constraint conditions. The formula **(1)** is the objective function in the linear programming.

Normally, for a specific objective function, there are quite a lot dimensions and variables. To simplify the complexity of given problem, the linear programming model, normally, was constructed with limited factors.
So, it is necessary to construct a dynamic intelligent model for intensifying financial investment prediction.

2.2 Neural Network

As what we knew, all the messages what human can feel are dispatched by network system with neuron and delivered to brain for further decision making. Neural network [8] which was defined in information technology simulates the operation, transmits the messages from sender through given activation function in each "cell" to receiver.

As the definition of neural network mentioned above, any cell in neural network normally gives different activation function within it. A sample of a cell in neural network can be depicted as the figure as below:
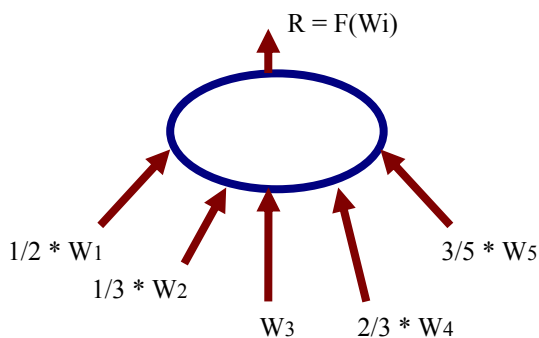

Figure 2 : A Sample of A Cell in Neural Network

where, for each input W_i = 0 or 1

$$F(W_i) = 2/3, \quad \text{if } 1/2\ W1 + 1/3\ W2 + W3 + 2/3\ W4 + 3/5\ W5 \geq 1.5$$
$$= 0, \quad \text{if } 1/2\ W1 + 1/3\ W2 + W3 + 2/3\ W4 + 3/5\ W5 < 1.5 \ \text{........}\textbf{(4)}$$

The value R is the return of activation function in the given cell. It got the 5 input sensors and forward to next stage (may be the other cell). The value 1.5 for function $F(W_i)$ is the "Threshold Value" for the cell's activation function. Each input which is associated with a "weight" can be defined as a factor for decision making in R. Each "weight" for corresponded "input" is normally independent to the other "weight" for the cell in neural network.

2.3 Classifier System

Classifier System [9] is the major research model for evolutionary computation in artificial intelligence. It is an intelligent learning mechanism with rules of expertise, messaging between rules and parallel process. Within the organization of classifier system, for intensifying the message delivery between rules, the Bucket Brigade Algorithm [10] was taken for solving Credit Assignment [11] in system. In addition, for self-creating new rules, classifier system was improved as a new expert system which can be the rules set with genetic algorithm. Each rule adopted in the system is treated as a *classifier*. Therefore, the operational mechanism for the whole classifier system is constructed on the evolutionary concept with information transmission and credit exchange among all classifiers. The system structure of whole classifier system can be depicted as figure 3：
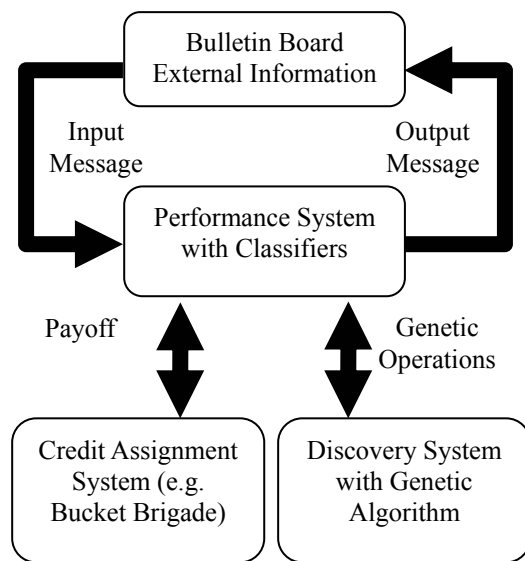

Figure 3 ：The System Structure of Classifier System

In the classifier system, the Performance System Module is located on kernel [12]. It is also the system module which connects to message outside. It is looked like an expert system but not limited on specific knowledge domain. Although it is rule-based system module, however, it still needs the additional system which can help to process the outside messages via information transmission, high degreed standardized action and parallel processing capabilities, and can tell the advantages from each classifier in the system.

The 2nd major system in classifier system is Credit Assignment System which can tell the advantages from different classifier, and evolve them via tuning credit. Normally the Bucket Brigade Algorithm was taken for processing the functionality. According to the definition of credit assignment, the Bucket Brigade Algorithm is designed for telling the right rules under a rule-based classifier system. Also by the Bucket Brigade Algorithm, better rules will be rewarded with more credits and worse rules will be punished. Each classifier in the credit assignment system indicates its own credit level.

Through the Bucket Brigade Algorithm the credit level for each classifier will be tuned by corresponded contribution in outside message handling. Also, the classifier can bid and obtain the right to handle outside message if it got highest credit level among all competitive classifiers.

The 3rd major system in classifier system is Rule Discovery System[13]。For the evolution after the competition among all classifiers, the portion of useful classifier is probably the minority in the whole classifier rule base. With the minority portion of classifier, it cannot be the answer to find the best set of classifiers so that the new classifiers (rules) should be generated via certain experience and evolutionary criteria. That is, the new classifiers are expected to generate either from existed excellent classifiers, or changing existed classifiers.

2.4 The Factors of Security Financial Investment

Security financial investment must be defined in term of market behavior. The market behavior, from fundamental viewpoint, is the supply – demand operations in term of economic activities [14]. The pricing is determined by the supply – demand operations, too.

The impact to price from supply – demand operations cannot be briefly explained with marketing trading. For buyers in stock market, the investment can be defined as two portions: stocks on hand and stakes for buying. Of course, for sellers in stock market, the investment can be defined with opposite way: stakes on hand and stocks for selling. Therefore, the timing for tuning stocks and stakes is taken as the strategy of investment.

In addition, for considering the balance of supply – demand relation made by quantity and price in stock market, the factors of analysis including technique, fundamentality, industry development, macro economics, information and stake, are the keys [15]. The motivation for investment including venture, risk prevention and profit locking, drives the balance of trading market in terms of operation model and momentum [16]. These factors above were discussed in the article.

2.5 Buffett's Criteria in Financial Investment

The philosophy of Buffett's financial investment is: "Search and invest the healthy enterprise entitiy if its stock price is much underestimated. Keep the stocks as long-term then the profit generated via compound interest will return." Therefore, the enterprise that Buffett preferred to invest got the characteristics listed as below [17]:

1. The enterprise gets the position of monopolization. The population of products is good. Business is

reliable and can be developed as well in the future.

2. The enterprise got reliable financial situation. The management performance is excellent. The capital investment is little and cash flow is sufficient.

3. If the enterprise is found by the conditions above, then evaluate the related internal value thereafter. If the current stock price of the enterprise is much less than the value after evaluation (normally the current stock price is 30% less than internal value), then the enterprise is deserved to invest.

When Buffett found the enterprise which met the conditions mentioned above, then he usually ignored the oscillation of stock price, funded quite a lot stakes and bought significant portion of stocks, as the way to purchase the enterprise. Buffett kept these stocks with long-term way. The timing he sold the stock was determined with the following conditions:

1. The current stock price is more than the internal value of the enterprise after evaluation.

2. The growth of aimed enterprise becomes slow.

3. More stakes are needed for better target enterprise.

3. THE OBJECTIVE FUNCTION OF THE INTELLIGENT MODEL

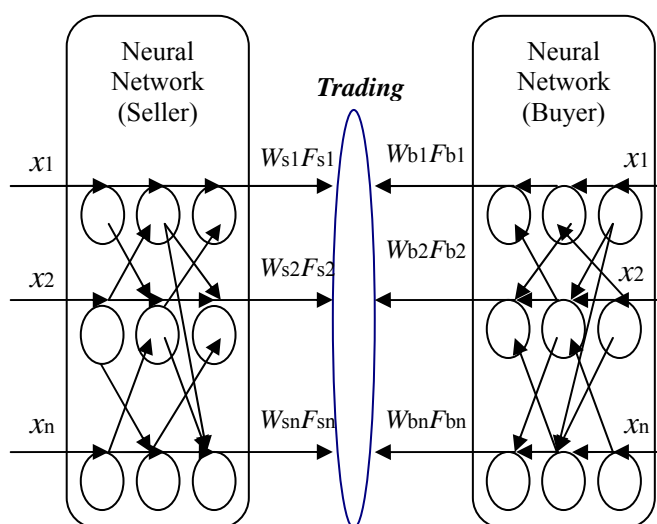The operation of this intelligent model with classifier-based neural network and Buffett strategy can be explained by Figure 4:

Figure 4：The Intelligent Model with Classifier-based Neural Network and Buffett Strategy

In Figure 4, WsiFsi and WbiFbi stand for the investment decision making information for the sellers and the buyers. Take the sellers as an example, Fsi represents the ith classifier of the seller party in the neural network,

and Wsi symbolizes the weighted function of the classifier Fsi. Formula (7) and (8) illustrate the definitions of these two function variables for the buyer party in the investment model, and the objective function is illustrated in formula (5) and (6).

Object function： $minimize \left| P_r(t) - P(t) \right|$ ……..(5)

Subject to:

$$P(t) = P(t-1) + \sum_{i=1}^{M} F_{bi}(t-1) \times W_{bi}(t-1) \dots(6)$$

where

$$F_{bi}(k) = PE_{stock_i} \times EPS_{stock_i} \times \sum_{k=t-10}^{t-1} PBT \times \sum_{k=t-12}^{t-1} GRP$$

……(7)

$W_{bi}(t-1)$ = the proportional weight in all classifiers of stock i in time t-1 ……….(8)

$P_r(t)$ denotes the real stock price in time t. $P(t)$ is the expected price after investment. $P(t-1)$ represents the present stock price before investment. The neural function in classifier system is shown in formula (6) where M is the number of stocks that $F_{bi}(t)$ and $W_{bi}(t)$ are adopted. We can observe the behavior of $F_{bi}(t)$ by formula (7). $W_{bi}(t)$ represents the weighted function in time t, as shown in formula (8). The object of this model, as stated in the objective function shown in formula (5), is to minimize the difference between $P(t)$, the expected stock price, and $P_r(t)$, the actual stock price in time t.

Obviously these functions $F_{bi}(t)$, $F_{si}(t)$, $W_{bi}(t)$, and $W_{si}(t)$ which determine the value of $P(t)$, is executed in the neural network. Say for the buyer, $W_{b1}(t)$ is the weighted function of $F_{b1}(t)$, $W_{b2}(t)$ is the weighted function of $F_{b2}(t)$, $W_{b3}(t)$ is the weighted function of $F_{b3}(t)$... and so on. $F_{b1}(t)$, $F_{b2}(t)$, and $F_{b3}(t)$ themselves are analyzable functions, therefore there exists respective parameters for each $F_{bi}(t)$. This kind of nested neural network structure befits the linear programming model well.

Defining $F_{bi}(t)$ and $W_{bi}(t)$ is the key issue to construct the most effective linear programming model within neural network framework. In this article, we use the "Divide and Conquer" to discover the best factor and choose the weights. The factors in the neural network framework, resulting in the linear programming model, build up a decision support system for the portfolio investment.

However, with the characteristics of dynamic linear programming, the analysis of neural network can be tuned. On the other hand, the static linear programming actually is far away from the real world. The stock investment cannot rely on such kind of model only because it will be distortive when the factors and stock environment start to change.

Certainlly, the functions including $F_{bi}(t)$、 $F_{si}(t)$、$W_{bi}(t)$ and $W_{si}(t)$ can be the other dynamic sub-objective functions. The precision of the related linear programming is determined by design scope, cost and the degree of detail. In the article, the way to improve the precision of objective function will be built on the realization on definition of dynamic parameters.

4. THE PRACTICE OF INTELLIGENT MODEL OPERATION

There were 6 samples taken for the coming experiment. However, it did not indicate the all criteria of Buffett knowledge. Also, the rules depicted from the given 6 samples do not show up the know how of the whole research of security investment. The intelligent model for security investment with classifier system, neural network and linear programming is designed for inputting more rules or knowledge, such as Buffett strategy and investment criteria, can be input and transformed as the classifiers and be evolved in the intelligent model.

According to related reference regarding to the research of Buffett investment strategies [17][18], the rule of 6 assumed sample classifiers and corresponded format can be defined as below:

1. Classifier_001：To retrieve stock if current price got 30% difference less than internal value of enterprise.

Condition of Classifier				Action		State			
#	0	0	0	0	1	0	1	0	1

2. Classifier_002：To retrieve stock if current price got 40% difference less than internal value of enterprise.

Condition of Classifier				Action		State			
#	0	0	1	0	1	0	1	0	1

3. Classifier_003：To retrieve stock if current price got 50% difference less than internal value of enterprise.

Condition of Classifier				Action		State			
#	0	1	0	0	1	0	1	0	1

4. Classifier_004：To retrieve stock if current price got 60% difference less than internal value of enterprise.

Condition of Classifier				Action		State			
#	0	1	1	0	1	0	1	0	1

5. Classifier_005：To retrieve stock if current price got 70% difference less than internal value of enterprise.

Condition of Classifier					Action		State		
#	1	0	0	0	1	0	1	0	1

6. Classifier_006：To retrieve stock if current price got 80% difference less than internal value of enterprise.

Condition of Classifier					Action		State		
#	1	0	1	0	1	0	1	0	1

For the 6 sample classifiers, the input message, output message, classifier function for telling the difference between current stock price and internal value of enterprise, and weighted function of bidding value can be depicted as below:

■ Input Message：including stock ID, PE, EPS, the profit rate before tax for past 10 quarters, revenue growth rate for past 12 months, the current price of the stock.

■ Output Message：same as input message, including stock ID, PE, EPS, the profit rate before tax for past 10 quarters, revenue growth rate for past 12 months, the current price of the stock.

■ Classifier Function to Tell the Difference：((PE) X (EPS) X (the profit rate before tax for past 10 quarters) X (revenue growth rate for past 12 months)) X (Condition)% >= (current price of stock).

■ The weighted function of bidding value：10% of the proportional weight in all classifiers.

The factors to evaluate stock value can be depicted with PBT (The Profit before tax), S.P (Current Stock Price) and margin is described as Table 1 as below：

Table 1：The Factors To Evaluate of Stock Value

EPS	PE	12M GRR	PBT	Value	<Date> S.P	Margin
2.40	20.00	3.04%	-0.24%	49.34	20.5	140.6%

According to the message format defined above, the stock value which is evaluated by classifier can be depicted as formula as below:

Stock Value = EPS X PE (in Industry) X (12M GRR) X PBT ………(9)

In the Table 1, 12M GRR (Growth Rate in term of Revenue) indicates the growth rate in term of monthly revenue in past 12 months. PBT indicates the profit rate before tax in past 10 quarters. Certainly, the regulation in the classifier is not necessary calculated by mean value but by the other buffett investment philosophy. For easily describing how to transform buffet

investment strategy as a classifier, the assumed factors and regulation mentioned above are taken for designed as "Buffett Classifiers" for practice.

Furthermore, why the both "12M GRR" and "PBT" are taken for designing a type of "Buffett Classifiers"?

1. According to the research of Buffett investment strategy, for preventing the error caused from stock price oscillation, the time period which is taken for information collection must be longer. The time period with 12 months or 10 quarters is a proper and reasonable default value to converge the performance of business operation and stock price.

2. The internal value of stock price for given enterprise, EPS and PE are the fundamental factors. However, the value of enterprise should be assessed according to operation performance and capability to make profit. Therefore, the factors "12M GRR" and "PBT" are taken as the parameter to evaluate the stock price. Note that the Buffett's attitude of stock investment was similar to "purchase the enterprise" rather than the gamble way.

So, the minimization of difference between **Pr(t)** and **P(t)** is objective function in the article. This is the design target for the proposed intelligent model. The mathematic characteristics in the intelligent model are also the research objectives in the article.

Note that the criteria within the assumed classifiers are not indicated high precision in stock price prediction. Probably some stronger classifiers have shown right assessment via giving internal value for the related enterprise. It must have some other weaker classifiers that never give right prediction. The point in the article is "the environment" for rules evolution from the structure and mechanism in the proposed intelligent model. The stronger classifiers that provide right answer in stock price prediction can be evloved through more investment strategies and learning via the genetic evolutionary process.

5. CONCLUSION

Through the research and practice in the article, the conclusion and additional issues were listed as below：

1. The intelligent model for stock investment with Buffett strategy, classifier system, neural network and linear programming got a lot of advantages in system learning and intelligence evolution. Any kind of valuable knowledge, even wisdom, such as Buffett stragey in stock investment, can be transformed and deliver into the intelligent model.

2. Through the intelligent model for stock investment, especially follow the Buffett criteria, the performance to make profit will not be carried in

very short time period. The basic learning cycle is stilled required.

3. The intelligent model is constructed with classifier system, neural network, fundamental financial factors and Buffett investment strategy. Obviously it integrated the research fields in artificial intelligence and financial investment. Through the study, except the useful rules can be adopted and evolved in the intelligent model, the rules with high performance of financial investment can be retrieved from the system operation.

4. All the samples and assumed classifiers are the basic objects for practice in the intelligent model. With longer practice, around more than half or 1 year, the precision of the intelligent model and stronger classifiers would be found.

5. The oscillation rate in linear credit function can be the advanced issue for research in the intelligent model. Also, the risk problem of the credit distribution among all classifier is deserved to discuss. The information in tendency or habitual domain for each classifier can be reveal from the credit assignment and genetic evolution. It would get the potential risk if no superior advisable intelligent model manages the operational intelligent model.

6. The variance beyond the system prediction should be considered. Therefore, the knowledge for high degree of stock price oscillation should be taken in linear programming.

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