Application of Fuzzy time sequence in stock prediction

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Abstract

Nowadays, more and more people take part in the stock-market actively, and the stock prediction has been one of the hot topics .Fuzzy time series are used for forecasting price of the stock as the first time in this paper. According to history data of stock price, we could predict the stock price at next time or at multiple moments, it will provide the theoretical basis for buying or selling time reasonable. At first, it introduces the correlation concepts of the fuzzy time sequence in this paper, and then we use the stock price of a listed company each time of one day as case study, and apply the fuzzy time series to predict the stock price. From mathematics view, we forecast the buying and selling time of stock reasonably. It is of great practical significance.

1. Introduction

Fuzzy time sequence is a part of Fuzzy mathematics. It is a group of fuzzy numerical sequences according to the time sequence. Application of the mathematics statistics in dealing with the fuzzy numerical sequences is to forecast the tendency of future. The basic principles are as follows: first, we have to admit that the development has its historical continuity. We could conjecture the trend of what we study. Moreover, we have to consider the randomness of the development, so we should deal the history data with weighted mean of statistical analysis.

It is well known that stock price fluctuation is effected by national policy enterprise management and other kinds of factors. We only consider the history data about stock, not other social factors when we apply Fuzzy time series to stock. So stock investors could connect this method with the social factors which influent the stock price to forecast the stock price, therefore increase the probability of making a profit.

2. Correlation conceptions of fuzzy time sequence

Definition 1 Let $\langle \alpha, a, \beta \rangle$ be triangular fuzzy number, the mark is $\tilde{a}$, where a is the kernel of the Fuzzy number, its membership function is

For c=0， $\langle a,0\rangle(x) = \begin{cases} 1, & x=a \\ 0, & x \neq a \end{cases}$

For $c \neq 0$

$$\langle a,c\rangle(x) = \begin{cases} 1-\dfrac{x-a}{c}, & |x-a| \le c \\ 0, & \text{otherwise} \end{cases}$$

Definition 2 Using $X(t)$ to express a general time series, where it is temporal variable, we fetch some finite points of equal time intervals $t_1 < t_2 < \cdots < t_n$, denoted as $X(t)$: $x(t_1), x(t_2), \cdots, x(t_n)$ or simplified form as $X(t)$: x_1 , x_2 , $\cdots$ x_n .

Assume that $X(t)$: x_1 , x_2 , $\cdots$ x_n is a time series, and that T=$\{t_1 < t_2 < \cdots < t_n\}$, and M is a nonempty Fuzzy set on T, that is M $\in \mathbb{F}$ (T) $\setminus \{\varnothing\}$ .Then

$$\bar{x}_f = \frac{\sum_{i=1}^{n} x_i M(t_i)}{\sum_{i=1}^{n} M(t_i)}$$

is called Fuzzy mean value of time series $X(t)$ with the restraining of M.

Definition 3 Suppose that $Y(t_i) \subseteq \mathbb{R}$ ($i = 1,2,\cdots,n$) , $\tilde{x}_i = \tilde{x}(t_i) \in (Y(t_i))$, then $\tilde{X}(t): \tilde{x}_1, \tilde{x}_2, \cdots, \tilde{x}_n$ is called a Fuzzy time sequence.

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Definition4 Suppose the Fuzzy time sequence $\widetilde{X}(t): \tilde{x}_1, \tilde{x}_2, \cdots, \tilde{x}_n$, where $\tilde{x}_i = \langle \alpha_i, x_i, \beta_i \rangle \quad (i = 1, 2, \cdots, n)$, $T = \{t_1, t_2, \cdots, t_n\}$, $M \in \mathbb{F}(T) \setminus \{\varnothing\}$. Then $\tilde{x}_f = \dfrac{\sum_{i=1}^{n} M(t_i) \cdot \tilde{x}_i}{\sum_{i=1}^{n} M(t_i)}$ is called Fuzzy mean value of $\widetilde{X}(t)$ with the restraining of M.

Definition 5 Suppose a time sequence $X(t): x_1, x_2, \cdots x_n$ and a nonempty normal Fuzzy set $M_i \in \mathbb{F}(T) \setminus \{\varnothing\}$ ($i = 1, 2, \cdots, n$) on T= $\{t_1 < t_2 < \cdots < t_n\}$. Then $X_M^{(1)}(t): x_1^{(1)}, x_2^{(1)}, \cdots, x_n^{(1)}$ is called single moving average sequence with the restraining of M_i, where

$$x_i^{(1)} = \frac{\sum_{i=1}^{n} M_i(t_j) x_j}{\sum_{i=1}^{n} M_i(t_j)}, \quad i = 1, 2, \cdots, n.$$

Moving average again based on the single moving average sequence. Correspondingly, the sequence $X_i^{(2)}(t)$ is called double moving average sequence of $X(t)$.

3. Application to predict the stock price

3.1 Predicting the stock price at the next time

Example: These stock prices are from opening quotation to 2：00pm of an enterprise a certain day (we record it every half an hour) as the table 1 demonstrates: Where t_i expresses time, $x_i^{/}$ expresses the stock price at time t_i (unit: Yuan)

Table1

t_i	09:30	10:00	10:30	11:00	11:30	13:00	13:30	14:00
$x_i^{/}$	11.82	12.03	12.37	12.01	11.76	11.45	12.19	12.52

Firstly, we need structure a group of fuzzy numbers about the stock price from the above data, the structure method is as follows:

Let $u_i = \max\{x_{i-1}^{/}, x_i^{/}, x_{i+1}^{/}\}$,

$v_i = \min\{x_{i-1}^{/}, x_i^{/}, x_{i+1}^{/}\}, \quad i = 1, 2, \cdots, 7.$

While $u_1 = \max\{x_1^{/}, x_2^{/},\}$, $v_1 = \min\{x_1^{/}, x_2^{/},\}$

$u_8 = \max\{x_7^{/}, x_8^{/},\}, \qquad v_8 = \min\{x_7^{/}, x_8^{/},\}$

$$c_i = \frac{1}{2}(u_i - v_i), \quad x_i = \frac{1}{2}(u_i + v_i)$$

c_i expresses the fluctuation index of the stock price, x_i expresses the fuzzy value of the stock price.

We can obtain x_i and c_i by means of calculation, see table 2.

Table 2

t_i	09:30	10:00	10:30	11:00	11:30	13:00	13:30	14:00
x_i	11.93	12.10	12.19	12.07	11.73	11.82	11.99	12.36
c_i	0.105	0.275	0.180	0.305	0.280	0.370	0.535	0.165

Obviously, the closer to the prediction, the greater will be influence on them. When the time series is long (for example, if we choose the stock price for more than two days to list in the table), the result can not reflect the tendency of recently time. Then, we can establish a concept of "recent" which is called "J" in the universe of discourse $T = \{t_1 < t_2 < \cdots t_n\}$, where J (t) is the membership function.

Let the corresponding of the stock price at 11:00 in the table is the initial value of the Fuzzy Set J.

And then $J(t) = \dfrac{0.2}{11:00} + \dfrac{0.4}{11:30} + \dfrac{0.6}{13:00} + \dfrac{0.8}{13:30} + \dfrac{1}{14:00}$.

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We can get $\sum_{i=1}^{8} J(t_i)$ =3 , And $\hat{x}_9 = \frac{\sum_{i=1}^{8} J(t_i)\tilde{x}_i}{\sum_{i=1}^{8} J(t_i)} = \left\langle \frac{1}{3}\sum_{i=1}^{8} J(t_i)x_i, \frac{1}{3}\sum_{i=1}^{8} J(t_i)c_i \right\rangle =$ $\langle 12.05, 0.329 \rangle$.

$\hat{x}_9$ means the stock price at 14：30 in this example. In order to predict x_{n+1} , we can use the method of the single Fuzzy moving average, take $\hat{x}_{n+1} = x_n^{(1)}$ as the estimated value of x_{n+1}.

From the result we can see, compared with the stock price at 14:00 this day, the price will decline at 14:30, and the stock investors can choose "sell" now, this method suits short-term stock better.

3.2 prediction of the stock price at multiple moments

If we only predict the stock price at the next time, we could not judge the whole tendency of the stock, under most circumstances, we need predict the stock price at multiple moments and judge that it will increase or decrease. Hence, it should "buy" or "sell" can be determined.

We can let the average change ration of the second Fuzzy moving average sequence used as the tendency change rate, that is $\bar{b} = \frac{1}{n-1}\sum_{i=2}^{n}(x_i^{(2)} - x_{i-1}^{(2)})$.

Similarly, we use the concept of recent, its membership function is $J(t)$, and then the recent change ration of the second Fuzzy moving average sequence is $b_J = \frac{\sum_{i=2}^{n}(x_i^{(2)} - x_{i-1}^{(2)})J(t_i)}{\sum_{i=2}^{n} J(t_i)}$.

For the given positive integer k (extrapolation cycle), we take $x_n^{(1)}$ as the initial value of the prediction, then the prediction value of the time series is $\hat{x}_{n+k} = x_n^{(1)} + b_J k$.

Example: Continue to use the data in Table 2, take M_i as symmetrical triangular fuzzy number $\langle i, 3 \rangle$, which is

$$M_i(t) = \begin{cases} 1 - \frac{|t-i|}{3}, & i-3 \le t \le i+3 \\ 0, & \text{otherwise} \end{cases}$$

We can get the single and double Fuzzy moving average sequence $X(t)$ under the constraint of M_i by means of calculation, as table 3 shows. $X(t)$ expresses the stock prices corresponding to time t_i, $X_M^{(1)}(t)$ expresses single Fuzzy moving average sequence, $X_M^{(2)}(t)$ expresses double Fuzzy moving average sequence.

Table 3

t_i	09:30	10:00	10:30	11:00	11:30	13:00	13:30	14:00
$X(t)$	11.93	12.10	12.19	12.07	11.73	11.82	11.99	12.36
$X_M^{(1)}(t)$	12.01	12.07	12.06	12.00	11.90	11.92	12.00	12.14
$X_M^{(2)}(t)$	12.04	12.04	10.69	11.99	11.96	11.97	12.00	12.06

We still suppose the stock price at 11：00 is the initial value in this Fuzzy set, and then the fuzzy set corresponding to the concept of recent in the universe of discourse $T = \{1, 2, \cdots, 8\}$ is

$$J = \frac{0.2}{11:00} + \frac{0.4}{11:30} + \frac{0.6}{13:00} + \frac{0.8}{13:30} + \frac{1}{14:00}$$

It can be obtained that $\sum_{i=1}^{8} J(t_i)$=3.

And that, the average value of the recent variation rate of the second Fuzzy moving average sequence is

$$b_J = \frac{\sum_{i=2}^{8}(x_i^{(2)} - x_{i-1}^{(2)})J(t_i)}{\sum_{i=2}^{8} J(t_i)} = 0.325$$

And $x_8^{(1)}$=12.14，based on $\hat{x}_{n+k} = x_n^{(1)} + b_J k$, it can be obtained that

$\hat{x}_9$ =12.47 $\hat{x}_{10}$ =12.79 ……

$\hat{x}_n$ =12.14＋0.325n

We can forecast the stock price each time ,and we can see that after the double moving average sequence are

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calculated, as long as we calculate b_J, the fluctuation tendency of Stock Price can be predicted. When b_J >0, it means that this stock price shows a tendency towards going up, under this condition, it should be bought. When b_J <0, the situation is opposite, that is it should be sold. The proposed method suits the investors of middle-swing trading better.

4. Conclusions

Fuzzy mathematics and the stock forecasting are combined in this paper. The stock price was forecasted reasonable by using Fuzzy time series of Fuzzy mathematics. This method is simple and easy to master; it is one of the bases of stock prediction used by the stock investors. If we make the methods presented in this paper linked with the realistic factors which affect the stock, the prediction will gain better results. With more and more people take part in the stock market, this method must have a good prospect.

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Authors' brief introduction

Zou Kai-qi (1944-), male, professor, doctor tutor, the mainly research aspects are fuzzy information processing, artificial intelligence and neural network.
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