The Analysis and Prediction of Stock Price

Tao Xing, Yuan Sun, Qian Wang, Guo Yu
International School of Software
Wuhan University
Wuhan, China
e-mail:xingtao@whu.edu.cn, cjchsun@hotmail.com

***Abstract*—Nowadays, the stock market has attracted more and more people's attention with its high risk and high returns, and forecasting method of stock price also emerge in an endless stream, such as nonlinear regression. In this paper, we introduce a kind of method based on Hidden Markov Model to forecast stock price trend. Which is different from the existing stock prediction, this paper attempts to find the hidden relationship existing between the stock prices, and corresponds to the Hidden Markov Model. The experimental result shows that, this method can get pretty accurate result, particularly effective in short period prediction.**

Keywords-Hidden Markov Model, Stock Price Forecast, Model Optimization

I. INTRODUCTION

Recently, with the development of society, the continuous development of market economy, the effect of the stock in the process of economic development is gradually, the stock market has become an important and inseparable part of the global economy. The fluctuation of the stock market [1-2] directly or indirectly affects our life and development of the country. Based on this, more and more people began to join the stock market, putting surplus funds into finance investment. However, as there is a certain degree of risk in the stock market investment, unpredictable trend of the stock prices has attracted more and more people to study and predict it.

In order to make an accurate prediction of the stock price, we must consider various factors which can affect the stock price. Only by fully understanding of these factors' change trend and effect, can reasonable and effective judgment be made. At this stage, in order to deal with the randomness and frequent fluctuation of the price which influenced by the superposition of multiple factors [3], nonlinear methods are usually used to predict the stock price. And the most common consideration is the use of nonlinear regression analysis [4-5]. Regression analysis is a kind of analysis method which can confirm the interdependent statistical quantitative relationship between two or more than two kinds of variable. It can analyze the inherent law of the data, and it is a very effective method. However, considering the existing situation of the stock market, regression analysis is not suitable. As we all know, impact factors of the stock price is very complex, which involves the internal factors of stock market, internal factors of the company, macroeconomic factors [6], policy factors and many others. Choosing which factors as variables in the regression analysis will be a very difficult thing. The selection of the influence factors accidentally will directly lead to great prediction deviation, resulting in unimaginable consequences.

For that reason, we must consider other methods for the corresponding research, in order to avoid the error caused by the variable selection. So, this paper mainly uses Hidden Markov Model on the stock market prediction [7-11]. Because a series of unknown factors cannot be observed directly in the stock market, we choose to correspond with the hidden states in a Hidden Markov Model, by estimating the state variables dimension and the structure characteristics, thus completing the prediction of the future. Hidden Markov Model is used in this paper to estimate the maximum likelihood values [12-13] of the price, matching the nearest value, and consider that the closest value and the price difference is the difference between the forecast data and the end of data. To make the prediction more accurate, we use the weighted average algorithm [14-15], avoiding the random prediction. Considering the different needs of different groups, our model is realized prediction analysis of different cycle.

In order to analyze the scientific validation of our method, we do an experiment analysis of the Hidden Markov Model and we make a comparison between our method and the regression analysis. Through experimental contrast, it is discovered that our Hidden Markov Model is better than the regression analysis. We abandon the traditional way which is easy but erroneous and come up with a new way overcoming the shortcomings of the traditional exist methods. It is valuable to find out a way to deal with the complicated situation.

In sum, our major objectives for this study should be finding a kind of method to make a pretty accurate, effective and stable prediction of the stock price. And we ensure that Hidden Markov Model is a terrific way to predict the stock price in a way, and it is particularly effective in predicting the short period price.

II. REGRESSION ANALYSIS PREDICTION METHOD

Traditional analysis will use the regression analysis prediction method and then predict the stock price according this.

Regression analysis prediction method, is based on analyzing the phenomenon of the market variables and the dependent variable relationship between the relevant, established the regression equation among the variables, and the regression equation as the predictive model, according to the changes of the number of variables in the forecast period to predict the dependent variable relationship mostly for correlation.

We selected a stock in January 16, 2013 to April 26,

2013 for the daily analysis using 66 data, and for the hour analysis using 280 data. We can collect the stock price information in the table 1.

TABLE 1 THE STOCK PRICE INFORMATION OF THE RECENT DECADE

Day	Price	Day	Price	Day	Price
1.16	17.82	2.22	19.12	3.26	22.14
1.17	17.74	2.25	20.01	3.27	22.15
1.18	18.33	2.26	20.85	3.28	20.02
1.21	19.7	2.27	21.02	3.29	20.12
1.22	20.48	2.28	23	4.01	20.39
1.23	20.05	3.01	23.06	4.02	20.44
1.24	19.45	3.04	21.75	4.03	20.45
1.25	19.15	3.05	23.93	4.08	19.93
1.28	21.07	3.06	24.25	4.09	19.94
1.29	21.38	3.07	23.74	4.10	19.4
1.30	21.33	3.08	22.86	4.11	19.41
1.31	21.1	3.11	22.63	4.12	18.9
2.01	22.43	3.12	21.72	4.15	18.56
2.04	22.01	3.13	22.09	4.16	18.75
2.05	21.78	3.14	21.67	4.17	18.49
2.06	21.86	3.15	22.2	4.18	19.1
2.07	20.85	3.18	21.35	4.19	20.24
2.08	20.75	3.19	21.5	4.22	20.23
2.18	20.9	3.20	23.1	4.23	19.08
2.19	20.81	3.21	22.96	4.24	19.4
2.20	20.3	3.22	23.03	4.25	18.83
2.21	19.6	3.25	22.76	4.26	18.7

Aiming at the stock price issue, we can do the prediction using the information above.

$$f(x) = a_1 * \exp(-((x-b_1)/c_1)\hat{}2)$$
$$+ a_2 * \exp(-((x-b_2)/c_2)\hat{}2) +$$
$$.....$$
$$+ a_7 * \exp(-((x-b_7)/c_7)\hat{}2)$$
$$+ a_8 * \exp(-((x-b_8)/c_8)\hat{}2)$$

Coefficients (with 0.95 confidence bounds)

$$a_1 = 10.41, b_1 = 32.13, c_1 = 2.81$$
$$a_2 = 17.63, b_2 = 41.68, c_2 = 5.127$$
$$a_3 = 19.61, b_3 = 17.94, c_3 = 11.95$$
$$a_4 = 11.71, b_4 = 28.22, c_4 = 4.334$$
$$a_5 = 15.53, b_5 = 49.94, c_5 = 7.12$$
$$a_6 = 19.27, b_6 = 63.59, c_6 = 10.4$$
$$a_7 = 14.95, b_7 = 1.423, c_7 = 11.19$$
$$a_8 = 12.46, b_8 = 36.08, c_8 = 3.284$$

It displays in the figure 1 as follow.

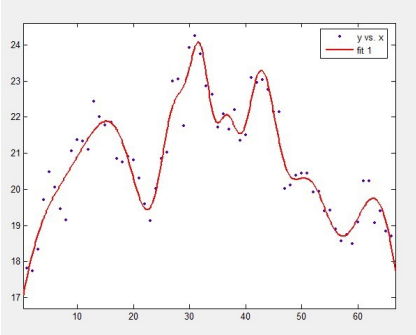

Figure. 1 Regression Analysis Prediction Method of Stock Price

In this way, we can get the stock price we want. We can make a prediction since May, 2013 using this method and compare it with the real data. The result of comparison is in Table 2.

TABLE 2 PREDICTION AND REAL DATA OF STOCK PRICE USING REGRESSION ANALYSIS PREDICTION METHOD

Day	Real	Prediction
5.02	18.91	17.3557
5.03	19.73	16.1237
5.06	20.31	14.7135
5.07	20.25	13.1851

Therefore, we can see the prediction accuracy easily. It is obvious that the regression is pretty well. It can predict the future condition.

However, this kind of method is not very accurate, it really has some disadvantages. Especially, it cannot make sure which factors are the most important, and which will play an irreplaceable role. So, we come up with another model, Hidden Markov Model.

III. HIDDEN MARKOV MODEL

A. Model Description

Hidden Markov Model is a parameter estimation and pattern recognition technique first proposed by Baum and Egon, is a kind of Markov Chain. It provides a probabilistic framework for multiple observations. Normally, we cannot directly observe the state of the Hidden Markov Model, but can understand the sequence of observation vectors, each vector of observations by some probability density distribution performance for a variety of state, each observation vector is generated by a response state sequence probability density distribution. The modeling process of Hidden Markov Model contains a doubly stochastic process, namely the basic random and function set, corresponding relationship that is visible state transition and the state and the observation result. Unlike the Markov Model, Hidden Markov Model, we observed only the final result, state cannot be observed directly, must establish the corresponding relationship between the two through a random function set. In order to get the set of functions, we need to get to observe the possible every state value, the initial probability distribution, the distribution state and transfer matrix, and then use the basic algorithm to calculate.

The prediction principle of Hidden Markov Model is: through observing and collecting data, analyzing and estimating the dimension hidden state variables which cannot be directly observed, estimating and identifying the structural characteristics, and predicting the future state and the output variables. Through contacting future trend analysis and historical data, using historical data for the parameter estimation of distribution, we can confirm the distribution of hidden states and observations, and predict current hidden state.

The principle of HMM can be expressed as follows.

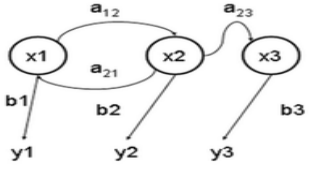

Figure 2. The Principle of HMM

x represents the hidden states of the HMM

y represents the observed state

a represents the transition probability

b represents the output matrix

Hidden Markov Model can be described using the five tuple (N, M, π, A, B). N express the number of states, M express the number of possible observation value of each state, π express the probability distribution of the initial state, A express state transition probability matrix which is independent of time, B express the observation value probability distribution matrix of the given state.

B. Hidden Markov Model Algorithm

Based on Hidden Markov Model theory, we will correspond to the forecast of the stock price. We also selected a stock in January 16, 2013 to April 26, 2013 for the daily analysis using 66 data, and for the hour analysis using 280 data. The data is still displayed in the table 1.

First, we determine the observation sequence we need to use. In this paper, we select the closing price of a stock in the corresponding period as the observation sequence, and we consider that it accords with the Hidden Markov Model. In this process, we select EM algorithm [16-17] for Gaussian Mixture Model (GMM) [18-20] of the corresponding implementation.

Every Gaussian Mixture Model is composed of some Gaussian Distributions. And the probability density function of the Gaussian Mixture Model is,

$$p(x)=\sum_{k=1}^{K} p(k)\,p(x\mid k)=\sum_{k=1}^{K}\pi_k \aleph(x\mid \mu_k,\Sigma_k) \quad (1)$$

To ensure the characteristics of the function, we need to use the maximum likelihood estimate and the likelihood function is,

$$\log\prod_{i=1}^{N} p(x_i)=\sum_{i=1}^{N}\log p(x_i)=\sum_{i=1}^{N}\log\sum_{k=1}^{K}\pi_k \aleph(x_i\mid \mu_k,\Sigma_k)$$

We use the EM algorithm to solve this function. The EM algorithm means Expectation-maximization. The E-step is to estimate the probability of data generation generated by every Gaussian. Aim to every data, the generation probability is,

$$\gamma(i,k)=\frac{\pi_k \aleph(x_i\mid \mu_k,\Sigma_k)}{\sum_{j=1}^{K}\pi_j \aleph(x_i\mid \mu_j,\Sigma_j)} \quad (3)$$

And the M-step is to differentiate the function (3).

$$\mu_k=\frac{1}{N_k}\sum_{i=1}^{N}\gamma(i,k)x_i \quad (4)$$

$$\Sigma_k=\frac{1}{N_k}\sum_{i=1}^{N}\gamma(i,k)(x_i-\mu_k)(x_i-\mu_k)^T \quad (5)$$

And $N_k=\sum_{i=1}^{N}\gamma(i,k)$.

The principle of the EM algorithm is iteration. If the likelihood function is convergence, we can stop the iteration.

After finishing the GMM, we use the selected observation sequence data to do the model training, and get the model parameter of HMM.

The model training can be operated by the HMM training function.

The transition matrix is:

$$transmat0=\begin{bmatrix} 0.11 & 0.11 & \dots & \dots & 0.11 & 0.11 \\ 0.11 & 0.11 & \dots & \dots & 0.11 & 0.11 \\ 0.11 & 0.11 & \dots & \dots & 0.11 & 0.11 \\ 0.11 & 0.11 & \dots & \dots & 0.11 & 0.11 \\ 0.11 & 0.11 & \dots & \dots & 0.11 & 0.11 \\ 0.11 & 0.11 & \dots & \dots & 0.11 & 0.11 \\ 0.11 & 0.11 & \dots & \dots & 0.11 & 0.11 \\ 0.11 & 0.11 & \dots & \dots & 0.11 & 0.11 \\ 0.11 & 0.11 & \dots & \dots & 0.11 & 0.11 \end{bmatrix}$$

Finally, we would like to calculate the maximum likelihood value. According to the characteristics of the Hidden Markov Model, based on the maximum likelihood traversal, we want to search the one which is the most close to the last data currently, and we think there are some floating connections, and we can forecast data by difference.

The maximum likelihood value we calculate is in table 3.

TABLE 3 THE MAXIMUM LIKELIHOOD VALUE OF THE OBSERVATION SEQUENCE

Day	Value	Day	Value	Day	Value
1.16	0.1572	2.22	-1.6903	3.26	-58.5116
1.17	-3.3798	2.25	-5.6162	3.27	-51.1184
1.18	1.4669	2.26	3.5798	3.28	-17.1208
1.21	-9.7223	2.27	-25.3745	3.29	-8.7723
1.22	-12.6571	2.28	-62.7146	4.01	-15.3887
1.23	-9.0208	3.01	-79.9441	4.02	-14.3602
1.24	-11.9964	3.04	-49.6697	4.03	-17.3809
1.25	-1.6321	3.05	-90.8336	4.08	-8.5339
1.28	-22.7624	3.06	-131.1855	4.09	-12.8373
1.29	-32.3286	3.07	-114.7861	4.10	-4.1785
1.30	-33.1686	3.08	-88.0971	4.11	-5.1941
1.31	-29.4139	3.11	-67.4956	4.12	-1.2763
2.01	-47.7079	3.12	-53.6665	4.15	0.4452
2.04	-46.7483	3.13	-44.3857	4.16	1.0955
2.05	-39.2017	3.14	-41.5304	4.17	1.0272
2.06	-46.1746	3.15	-53.2774	4.18	0.1093
2.07	-37.3018	3.18	-32.8972	4.19	-11.2988
2.08	-19.6633	3.19	-33.7178	4.22	-13.5122
2.18	-22.6939	3.20	-63.7855	4.23	-18.5139
2.19	-24.3465	3.21	-81.7285	4.24	-2.2274
2.20	-20.7854	3.22	-88.2939	4.25	-1.4618
2.21	-7.7049	3.25	-75.6249	4.26	-0.8662

The difference of the maximum likelihood value is in table 4.

TABLE 4 THE DIFFERENCE OF THE MAXIMUM LIKELIHOOD VALUE

Day	Value	Day	Value	Day	Value
1.16	1.0234	2.22	0.8241	3.26	57.6454
1.17	2.5136	2.25	4.7501	3.27	50.2522
1.18	2.3331	2.26	4.4460	3.28	16.2546
1.21	8.8561	2.27	24.5083	3.29	7.9061
1.22	11.7909	2.28	61.8484	4.01	14.5226
1.23	8.1546	3.01	79.0779	4.02	13.4940
1.24	11.1302	3.04	48.8035	4.03	16.5147
1.25	0.7659	3.05	89.9674	4.08	7.6677
1.28	21.8962	3.06	130.3193	4.09	11.9711
1.29	31.4624	3.07	113.9199	4.10	3.3123
1.30	32.3025	3.08	87.2309	4.11	4.3280
1.31	28.5477	3.11	66.6294	4.12	0.4101
2.01	46.8417	3.12	52.8004	4.15	1.3114
2.04	45.8821	3.13	43.5195	4.16	1.9617
2.05	38.3356	3.14	40.6643	4.17	1.8934
2.06	45.3084	3.15	52.4112	4.18	0.9755
2.07	36.4356	3.18	32.0310	4.19	10.4326
2.08	18.7971	3.19	32.8516	4.22	12.6461
2.18	21.8277	3.20	62.9193	4.23	17.6478

2.19	23.4803	3.21	80.8623	4.24	1.3612
2.20	19.9192	3.22	87.4277	4.25	0.5956
2.21	6.8387	3.25	74.7587	4.26	0

According to the result, we can predict the next value. The same as the regression analysis prediction method, we also predict the stock price in May using Hidden Markov Model and the result is displayed in the table 5.

TABLE 5 PREDICTION AND REAL DATA OF STOCK PRICE USING HIDDEN MARKOV MODEL

Day	Real	Prediction
5.02	18.91	18.36
5.03	19.73	20.89
5.06	20.31	19.13
5.07	20.25	19.71

IV. EXPERIMENTS ANALYSIS

In order to prove that the Hidden Markov Model we use can be well used in the stock market, we make a empirical analysis respectively on the Regression Analysis Prediction Method and the Hidden Markov Model Prediction Method, and compare the results, and draw the conclusion.

In order to avoid the singularity and contingency of the analysis, we select another stock A, and analyze respectively the daily data and five minutes data. The data is displayed in the table 6 and 7.

TABLE 6 THE DAILY DATA OF STOCK A IN THE LAST DECADE (2012.9.18-2012.12.25)

Day	Value	Day	Value	Day	Value
9.18	8.01	10.25	8.35	11.26	8.42
9.19	8.04	10.26	8.2	11.27	8.46
9.20	7.82	10.29	8.22	11.28	8.34
9.21	7.81	10.30	8.3	11.29	8.43
9.24	7.89	10.31	8.32	11.30	8.75
9.25	7.91	11.01	8.59	12.03	8.8
9.26	7.79	11.02	8.65	12.04	8.95
9.27	8.21	11.05	8.67	12.05	9.14
9.28	8.43	11.06	8.61	12.06	9.27
10.8	8.16	11.07	8.51	12.07	9.2
10.9	8.36	11.08	8.5	12.10	9.34
10.10	8.36	11.09	8.38	12.11	9.24
10.11	8.29	11.12	8.56	12.12	9.24
10.12	8.24	11.13	8.37	12.13	9.32
10.15	8.19	11.14	8.37	12.14	9.7
10.16	8.18	11.15	8.25	12.17	9.57
10.17	8.13	11.16	8.22	12.18	9.22
10.18	8.44	11.19	8.18	12.19	9.31
10.19	8.42	11.20	8.25	12.20	9.48
10.22	8.42	11.21	8.37	12.21	9.43
10.23	8.4	11.22	8.38	12.24	9.55
10.24	8.43	11.23	8.45	12.25	10.12

TABLE 7 FIVE MINUTE DATA OF STOCK A IN THE LAST DECADE (2013.5.3-2013.5.6)

Date	Value	Date	Value	Date	Value
1	11.58	23	11.55	45	11.29
2	11.61	24	11.54	46	11.27
3	11.61	25	11.52	47	11.27
4	11.6	26	11.48	48	11.27
5	11.62	27	11.41	49	11.28
6	11.67	28	11.42	50	11.35
7	11.68	29	11.44	51	11.38
8	11.67	30	11.41	52	11.4
9	11.66	31	11.42	53	11.42
10	11.66	32	11.46	54	11.4
11	11.63	33	11.43	55	11.36
12	11.62	34	11.42	56	11.38
13	11.59	35	11.45	57	11.37
14	11.54	36	11.45	58	11.35
15	11.55	37	11.39	59	11.33
16	11.6	38	11.4	60	11.31
17	11.59	39	11.39	61	11.33
18	11.59	40	11.39	62	11.35
19	11.6	41	11.43	63	11.34
20	11.62	42	11.36	64	11.35
21	11.57	43	11.34	65	11.34
22	11.56	44	11.34	66	11.35

A. *Regression Analysis Prediction Method*

We do the analysis using Regression Analysis Prediction Method and the regression result is displayed in the figure 3(Daily Data) and figure 4(Five Minute Data).

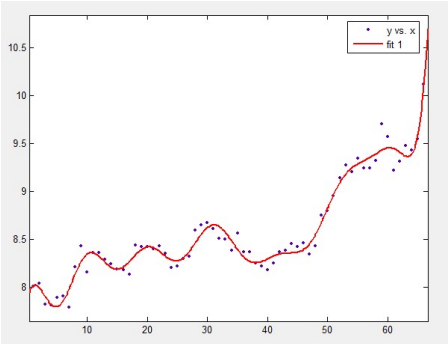

Figure 3. The Prediction Result Using Regression Analysis Prediction Method (Daily Data)

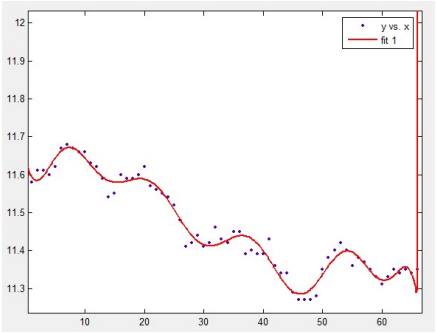

Figure 4. The Prediction Result Using Regression Analysis Prediction Method (Five Minute Data)

It is clear that the Regression Analysis Prediction Method can make a pretty good predict

Then, we make a prediction using the regression function and the result is displayed in the table 8(daily data) and table 9(five minute data).

B. *Hidden Markov Model Prediction Method*

The same as the Regression Analysis Prediction Method, Hidden Markov Model Prediction Method is used to predict the stock A, both daily data and the five minute data, as well. We show the result of daily data in the figure 5(daily data) and table 8.

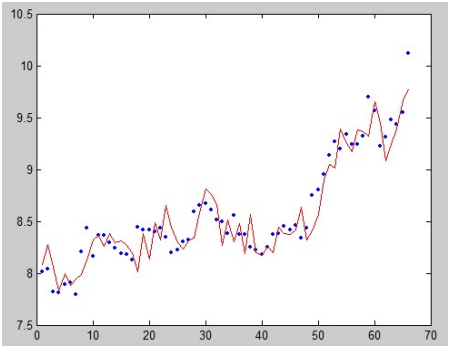

Figure 5. The Prediction Result Using Hidden Markov Model Prediction Method (Daily Data)

TABLE 8 THE PREDICTION DAILY DATA OF STOCK A USING HIDDEN MARKOV MODEL PREDICTION METHOD IN THE LAST DECADE (2012.9.18-2012.12.25)

Day	Value	Day	Value	Day	Value
9.18	8.08	10.25	8.65	11.26	8.37
9.19	8.28	10.26	8.44	11.27	8.42
9.20	8.06	10.29	8.29	11.28	8.64
9.21	7.83	10.30	8.23	11.29	8.32
9.24	8	10.31	8.31	11.30	8.41
9.25	7.88	11.01	8.34	12.03	8.57
9.26	7.94	11.02	8.58	12.04	8.9
9.27	7.99	11.05	8.81	12.05	9.05
9.28	8.13	11.06	8.76	12.06	9.01
10.8	8.32	11.07	8.66	12.07	9.39
10.9	8.36	11.08	8.27	12.10	9.25
10.10	8.26	11.09	8.51	12.11	9.17
10.11	8.38	11.12	8.3	12.12	9.38
10.12	8.29	11.13	8.48	12.13	9.36
10.15	8.31	11.14	8.19	12.14	9.32
10.16	8.27	11.15	8.57	12.17	9.65
10.17	8.2	11.16	8.2	12.18	9.45
10.18	8.01	11.19	8.17	12.19	9.08
10.19	8.38	11.20	8.26	12.20	9.24
10.22	8.14	11.21	8.2	12.21	9.39
10.23	8.49	11.22	8.44	12.24	9.66
10.24	8.32	11.23	8.38	12.25	9.78

Also, the result of five minute data is displayed in the figure 6 and table 9.

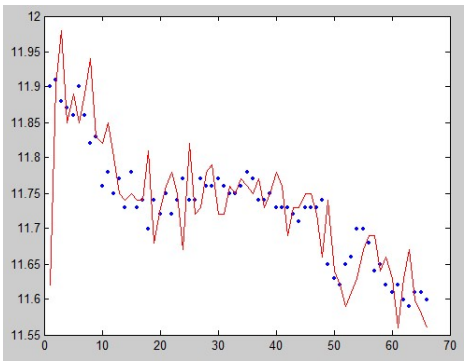

Figure 6. The Prediction Result Using Hidden Markov Model Prediction Method (Five Minute Data)

TABLE 9 THE PREDICTION FIVE MINUTE DATA OF STOCK A USING HIDDEN MARKOV MODEL PREDICTION METHOD IN THE LAST DECADE

Date	Value	Date	Value	Date	Value
1	11.62	23	11.75	45	11.75
2	11.9	24	11.67	46	11.75
3	11.98	25	11.82	47	11.72
4	11.85	26	11.72	48	11.66
5	11.89	27	11.73	49	11.74
6	11.85	28	11.78	50	11.64
7	11.89	29	11.79	51	11.62
8	11.94	30	11.72	52	11.59
9	11.83	31	11.72	53	11.61
10	11.82	32	11.76	54	11.63
11	11.85	33	11.75	55	11.67
12	11.8	34	11.77	56	11.69
13	11.75	35	11.76	57	11.69
14	11.74	36	11.75	58	11.64
15	11.75	37	11.77	59	11.66
16	11.74	38	11.73	60	11.63
17	11.74	39	11.75	61	11.56
18	11.81	40	11.78	62	11.63
19	11.68	41	11.76	63	11.67
20	11.73	42	11.69	64	11.6
21	11.76	43	11.73	65	11.58
22	11.78	44	11.73	66	11.56

C. Comparison of the two methods

In order to make an obvious comparison of the two methods, we list the prediction data and the real data. We can see the result according to the information and make a judge. The daily data is in the table 10.

TABLE 10 THE COMPARISON OF TWO PREDICTION METHOD (DAILY DATA OF STOCK A IN THE LAST DECADE)

Day	Real Value	Prediction Value (Regression Analysis)	Prediction Value (HMM)
1.21	11.13	11.108	10.19
1.22	11.76	12.6585	12.14
1.23	11.69	14.7768	12.39
1.24	11.95	17.3344	11.62
1.25	11.7	20.0587	11.88
1.28	12.06	22.5654	11.45
1.29	12.21	24.4316	11.81
1.30	12.67	25.2928	12.36
1.31	12.01	24.9351	13.13
2.1	11.96	23.3514	11.35
2.4	11.9	20.7415	12.11
2.5	12.33	17.4577	12.26
2.6	12.16	13.9155	12.59
2.7	11.88	10.5007	12.62
2.8	12.03	7.4997	11.71

Through calculation, the average error of the Regression Analysis Prediction Method is 6.6034, and the average error of the Hidden Markov Model Prediction Method is 0.49.

The five minute data is in the table 11.

TABLE 11 THE COMPARISON OF TWO PREDICTION METHOD (FIVE MINUTE DATA OF STOCK A IN THE LAST DECADE)

Day	Real Value	Prediction Value (Regression Analysis)	Prediction Value (HMM)
1	11.59	11.6784	11.61
2	11.61	11.7048	11.56
3	11.59	11.7351	11.62
4	11.61	11.7690	11.6
5	11.6	11.8061	11.59
6	11.6	11.846	11.59
7	11.6	11.8881	11.6
8	11.59	11.9319	11.59
9	11.56	11.9766	11.59
10	11.55	12.0214	11.55
11	11.5	12.0654	11.52
12	11.47	12.1077	11.48
13	11.43	12.1472	11.46
14	11.47	12.1829	11.4
15	11.48	12.2136	11.44
16	11.48	12.2383	11.48
17	11.49	12.2559	11.5

18	11.5	12.2651	11.5
19	11.51	12.2649	11.54
20	11.49	12.2542	11.47
21	11.47	12.2321	11.53
22	11.47	12.1975	11.49

Through calculation, the average error of the Regression Analysis Prediction Method is 0.505555, and the average error of the Hidden Markov Model Prediction Method is 0.021364. There is no denying that either the daily data or the five minute data, Hidden Markov Model is a good prediction method.

According to tables above, we can easily conclude that our Hidden Markov Model Prediction Method is obvious better than the traditional Regression Analysis Prediction Method. Although the Regression Analysis can be easier, it has a great fluctuation. This is a very dreadful thing especially in the stock market. We all know that the stock price changes frequently, we must forecast as accurately as possible. According to the result, the advantages of Hidden Markov Model are undisputed.

V. CONCLUSIONS

Different from the regression analysis prediction method and other forecasting methods, Hidden Markov Model tries to avoid the influence of factor selection, combination and transformation. This model make a smart choice which is using the implicit prediction, let the factors affecting the stock price contained in the hidden state model, so as to avoid unnecessary errors. So, the Hidden Markov Model can be used to predict the stock price. Considering the single forecast uncertainty and randomness, we make a little change of the original Hidden Markov Model algorithm. Considering the prediction of impact factor data, we do an average weighted factor, finish the improvement of the prediction accuracy, and reduce the investment risk. It is true that method for the stock market prediction is of great practical significance.

To sum up, as an important tool in the field of pattern recognition, modeling and prediction of Hidden Markov Model for multivariate financial time series provides a set of effective probabilistic analysis framework. Based on Hidden Markov Model, we select proper observed vector, the number of hidden state, the emission probability density functions, and identify the target time series change pattern. We choose pattern matching sequences by looking at the historical sequence, to generate a probability and statistics support the prediction results.

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