Predicting Stock Price Trend Using Candlestick Chart Blending Technique

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Abstract— **The paper deals with a technical analysis for stock price predictions using candlestick charts. The stock prices are apt to show no directional movements when there is no significant news, resulting in generating a series of noisy candlesticks. We propose a blending algorithm that combines candlesticks sharing certain price ranges into one candlestick to eliminate the noisy candlesticks. The paper discusses statistical measures on candlesticks to produce appropriate blended candlestick charts for the prediction. The experimental results on the Nikkei-225 stock average show that the blended candlesticks are successful in offering information for short-term stock price predictions. The performance of the proposed algorithm is measured showing that it can blend daily candlesticks of 25 years within two seconds.**

Keywords— Stock price prediction; Technical analysis; Blending Candlesticks; Candlestick charting; Nikkei stock average

I. INTRODUCTION

Stock trend prediction techniques play a crucial role to bring more people into market and encourage markets as a whole. There are two primary methods used to predict stock price movements and support investment decisions, i.e., fundamental analysis and technical analysis [1].

Fundamental analysis involves analyzing a company's financial data to determine the fair value of the company, and to forecast future stock value. Because of this analyzing process, most investors believe that fundamental analysis is mainly suitable for long-term prediction.

Technical analysis is based on the assumption that history repeats itself. It attempts to predict future stock price movements based on an examination of past stock price movements [2]. One of the important types of technical analysis is candlestick chart patterns [2][3], known as "candlestick charting." The candlestick chart patterns usually consisting of only a few consecutive candlesticks, providing short-term predictions for traders. Dozens of candlestick chart patterns are identified to be signals of bullish/bearish reversals and continuations.

The candlestick charting technique probably began sometime after 1850 [2]. Despite of its long history and popularity, mixed results are obtained in the studies using the candlestick charting technique. Negative conclusions to the predictability of candlesticks are reported [4]-[6], while positive conclusions are provided for several candlestick chart patterns by experiments on the U.S., European and the Asian stock markets [7]-[12].

The studies [4]-[11] adopt definitions using a series of inequalities with different parameters that specify candlestick patterns. Numerical definitions of candlestick patterns are still controversial issues. In addition, chart patterns don't necessarily occur in time series in a strict sense because stock price fluctuation continues after intervals of several days depending on announcements of important economic indicators, economic and political news, etc. [12]. The candlesticks during the periods are often recorded as overlapped sort-body candlesticks forming a series of noisy candlesticks.

The previous study [12] discusses a chart retrieval model with several parameters specifying candlestick patterns, and a use of the dynamic programming method named nLCSm, which is a numeric version of the longest common substring (LCS) algorithm. Though the previous study is effective in predicting future stock trends, it lacks in visibility because the dynamic programming method calculates all the necessary processes including skipping noisy candlesticks.

In this paper, we propose a systematic method that uses a candlestick chart blending technique [3][13]. The proposed method is applied to the Nikkei-225 stock average [14] to evaluate effectiveness. The contributions of this paper are as follows:

(I) An candlestick blending algorithm is developed to eliminate noisy candlesticks. The paper discusses how to estimate the proper value of parameters of the algorithm based on statistics of candlestick charts.
(II) The paper proposes a model for retrieving similar candlesticks featuring relative position among a stock price, 5-day and 25-day moving averages to decide whether the stock price occurs in high or low price zones.
(III) A graphical representation method is implemented to make evaluation of retrieval results easy.

The remainder of the paper is organized as follows. Section II gives some of the most related work. Section III gives backgrounds of the candlestick chart and an idea of chart blending. Section IV describes an algorithm of blending candlesticks with statistical considerations. Section V presents experimental results to retrieve similar candlestick charts for short-term price predictions. Section VI concludes the paper with our plans for future work.

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II. Related Work

Horton [4] examines candlestick patterns for 349 stocks finding little value in the use of them. Marshall, Young, and Cahan [5] conclude that candlestick patterns have no forecasting power on Dow Jones Industrial Average (DJIA) and the Japanese market. Tharavanij, Siraprapasiri, and Rajchamaha [6] investigate the profitability of several bullish and bearish candlestick patterns. Based on experiments, they conclude that any candlestick patterns cannot reliably predict market directions even with filtering by well-known stochastic oscillators [2].

Caginalp and Laurent [7] study and favorably evaluate the predictive power of eight three-day reversal candlestick patterns on the S&P500 stock index over the 1992-1996 period. They propose to define candlestick patterns as a set of inequalities using opening, high, low, and closing prices. These inequalities are taken over in later studies.

Goo, Chen, and Chang [8] define 26 candlestick patterns using modified version of inequalities that are proposed by Caginalp and Laurent. They examine these patterns on stock data of Taiwan markets, and conclude that the candlestick trading strategies are valuable for investors.

Goumatianos, Christou, and Lindgren [9] present a rule-based algorithm to detect hidden profitable candlestick patterns using daily stock data of the U.S. markets.

Zhu, Atri, and Yegen [10] examine the effectiveness of five different candlestick reversal patterns in predicting short-term stock movements using two Chinese stock indexes.

Lu, Chen, and Hsu [11] propose to apply candlestick trading strategies to U.S. stock indexes with several trend definitions. They find three-day reversal patterns are profitable when the transaction cost is set at 0.5%.

III. Model of Blending Candlesticks

This section introduces the formation of a candlestick. Candlestick patterns are a combination of one or more candlesticks. Principles of candlestick blending are presented.

A. Formation of Candlestick

A daily candlestick line is formed with the market's opening, high, low, and closing prices of a specific trading day [2][3]. Fig. 1 represents a typical candlestick. The candlestick has a wide part, which is called the "real body" representing the range between the opening and closing prices of that day's trading.

If the closing price is above the opening price, then a white candlestick with black border is drawn to represent a bullish candlestick. If the opening price is above the closing price, then a filled candlestick is drawn, representing a bearish candlestick.

The thin lines above and below the body represent the high and low ranges. These lines and are called "shadows" and also referred to as "wicks" and "tails." The highest price is marked by the top of the upper shadow and the lowest by the bottom of the lower shadow.

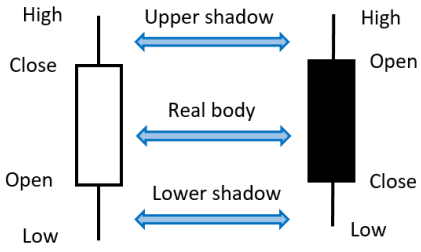

Figure 1. Candlestick formation

B. Samples of Candlestick Patterns

Dozens of candlestick patterns are identified and become popular among stock traders [2][3]. These patterns have colorful names like *morning star*, *evening star*, *three white soldiers*, and *three black crows*.

Fig. 2 shows the *morning star* pattern which is considered as a reversal signal to an uptrend when it appears in a low price zone or at a bottom. It consists of three candles, i.e., one short-bodied candle (black or white) between a preceding long black candle and a succeeding long white one. The pattern shows that selling pressure that was there the day before is now subsiding. The third white candle overlaps with the body of the black candle showing a start of a bullish reversal.

The opposite version of the *morning star* pattern is known as the *evening star* pattern shown in Fig. 3. The *evening star* pattern suggests a reversal signal to a downtrend when it appears in a high price zone or at the end of an uptrend.

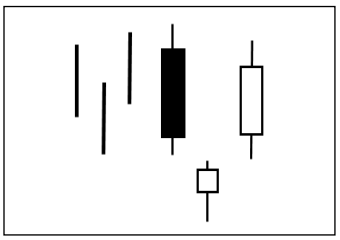

Figure 2. *Morning star* pattern

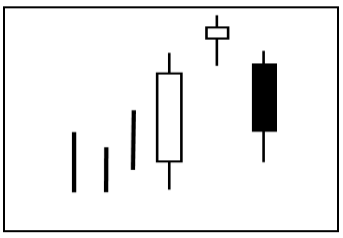

Figure 3. *Evening star* pattern

C. Blending Candlesticks

When there is no conspicuous news concerning economics, stock price fluctuation tends to move small. A series of small movements makes a stock trend uncertain. Candlesticks blending [3][13] is used so that we can get a clear idea of what's happening concerning price movements.

Fig. 4 depicts the principles of blending two candlesticks. The body of a blended candlestick is defined by the opening price of first candlestick, and the closing price of the second candlestick. The shadows of the blended candlestick are defined by the highest and the lowest between the two candlesticks. The blending processes are usually applied under the condition that the two bodies of the candlesticks are engulfed or overlapped.

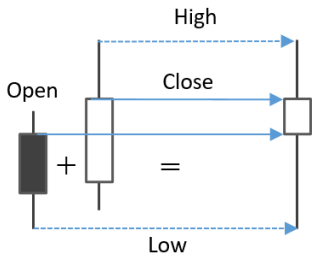

Figure 4. Principles of blending two candlesticks

It can be best understood that a blended version of candlesticks summarizes candlesticks with small price movements into ones with moderate price movements. The blended candlesticks allow traders to captures an essence of the candlestick patterns and to lead them to make right decision.

Although the principles are simple, most literature fails to make evident the criteria for applying the blending candlesticks, e.g., on what condition it starts and it ends.

D. Gaps as Separators

A gap in a candlestick chart is basically an empty space between one trading period and the previous trading period [2][3]. The gap is usually a result of an important economic announcement and can indicate a change of price trends. According to the chart pattern analysis, the gap breaks a series of consecutive price movements. This study employs the gap as a separator for breaking a series of consecutive candlesticks.

E. Statistics of Chandlesticks

Since a candlestick chart consists of consecutive candlesticks, it can be characterized by the several attributes calculated by the following formulas:

$$\text{Upper shadow}_0 = \text{high}_0 - \text{Max}(\text{open}_0, \text{close}_0) \quad (1)$$

$$\text{Lower shadow}_0 = \text{Min}(\text{open}_0, \text{close}_0) - \text{low}_0 \quad (2)$$

$$\text{Body length}_0 = \text{close}_0 - \text{open}_0 \quad (3)$$

$$\text{Change}_0 = \text{close}_0 - \text{close}_{-1} \quad (4)$$

$$\text{Gap}_0 = \text{Lower body price}_0 - \text{Upper body price}_{-1} \quad (5)$$

The subscript number "0" means the business day considered. "–1" indicates the day before the business day under consideration. Table I summarizes the statistics of the daily Nikkei stock average of 2,656 business days from Jan. 4, 2008 to Nov 5, 2018.

TABLE I. STATISTICS OF DAILY NIKKEI STOCK AVERAGE

Attributes	Occurences	Average	Deviation
Upper shadow (%)	2,559	0.276	0.332
Lower shadow (%)	2,559	0.298	0.354
Body length (%)	2,559	-0.035	1.199
Change (%)	2,558	0.030	1.604
Gap (%)	2,558	0.097	0.857

Fig. 5 shows the frequency diagram representing gap distributions. The number of occurrences is counted every 0.1%. It shows that the gap values roughly follow the normal distribution with the average of 0.097% and the standard deviation of 0.857%.

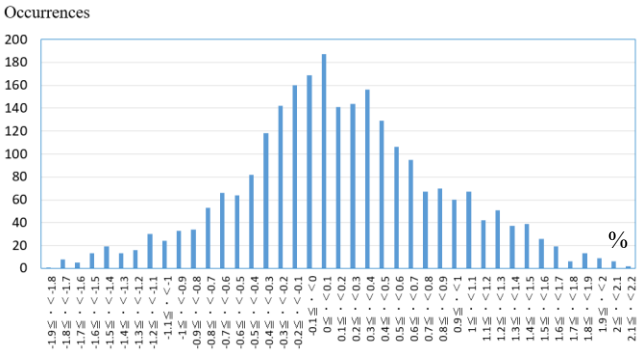

Figure 5. Frequency diagram of gap distributions

IV. EXPERIMENTS ON BLENDING CHANDLESTICKS

This section describes an algorithm to blend candlesticks. Candlestick blending is controlled by the value of a gap as a separator and the maximum number of candlesticks to blend. The results of candlestick blending are examined from the viewpoint of statistical measures.

A. Outline of Blending Algorithm

In the previous literature [3][13], a method for blending candlesticks is qualitatively described with words supported by some illustrations. It seems certain that there is a consensus that candlesticks sharing a common price range can be blended into a candlestick. This means that a gap of two adjacent candlesticks is appropriate to define the border of a series of candlesticks that should be blended.

Fig. 6 shows the pseudo code of the *Blending_candlestick* algorithm. The algorithm takes two parameters, i.e., *GapParam* and *MaxBlendCandles*. The *GapParam* parameter defines a threshold of a gap to blend candlesticks. The *MaxBlendCandles* parameter defines the maximum number of candlesticks to blend.

```
1 Blending_candlestick( float GapParam, int MaxBlendCandles ){
2     int Cnt= CloseP.length;      // Set the lines of candlestick data
3     float vUpperP= 0.0F;
4     float vLowerP= 10000000.0F;
5     for ( j = 0 ; j > -Cnt ; j-- ){ // For all candlestick data
6         int NBlend= 1; // Initialize the number of blended candlesticks
7         float vCloseP= CloseP[j];   // Set the last day's closing price
8         if( GapP[j] < GapParam ){   // If the gap is less than GapParam
9             do{
10                j--;                // Move to the previous day
11                float up= UpperP[j];
12                if ( up > vUpperP){
13                    vUpperP= up;  }       // Set the highest price
14                float lw= LowerP[j];
15                if ( lw < vLowerP){
16                    vLowerP= lw;  }       // Set the lowest price
17                float vOpenP= OpenP[j];     // Set the opening price
18                float xGapP= GapP[j];       // Get the gap
19                NBlend++;
20            } while ( NBlend < MaxBlendCandles && xGapP < GapParam );
21        }
22        // Save the blended candlestick data to file.
23        SaveFile(vOpenP, vUpperP, vLowerP, vCloseP, NBlend);
24    }
25}
```

Figure 6. Pseudo code of blending algorithm

It is assumed that the opening prices are stored in the array OpenP[]. OpenP[0] means the opening price in percentage of the business day considered. OpenP[-1] means the opening price of the day before the business day under consideration. It is also assumed that CloseP[], GapP[], UpperP[] and LowerP[] provide access to the closing price, gap, upper price and lower price data, respectively.

The blending algorithm in Fig. 6 is designed to perform the blending process toward the past. It continues for all candlestick data while a gap is less than *GapParam* and the number of blended candlesticks is less than *MaxBlendCandles* as described in the *while* loop terminate condition shown in line 20 of Fig. 6.

B. Results of Blending Experiments

Blending experiments are carried out by changing the *MaxBlendCandles* parameter to two to seven. The *GapParam* parameter is defined according to the statistics of the candlestick data of the daily Nikkei stock average as described in Section III.

Table II summarizes the results. The entry of the table shows the ratio in percentage calculated by the number of blended candlesticks divided by the number of the original candlesticks. In the experiments, the *GapParam* is set to the value of average plus some percentages of a standard deviation.

For example, "5% Dev." means the *GapParam* is 0.097 + 0.857*(25/100) = 0.3113 since the average is 0.097% and the standard deviation is 0.857% as described in Section III.

TABLE II. SUMMARY OF CANDLESTICK BLENDING

	2 Days	3 Days	5 Days	7 Days
1% Dev.	66.97%	57.43%	51.68%	50.47%
2% Dev.	66.89%	57.19%	51.45%	50.20%
3% Dev.	66.61%	56.72%	50.78%	49.57%
4% Dev.	66.38%	56.25%	50.27%	49.02%
5% Dev.	66.22%	55.94%	49.88%	48.55%
10% Dev.	65.09%	54.50%	48.01%	46.52%
15% Dev.	64.11%	52.78%	46.01%	44.18%
20% Dev.	63.17%	51.33%	44.21%	42.10%
25% Dev.	62.31%	50.12%	42.18%	39.91%
30% Dev.	61.10%	48.59%	40.07%	37.37%
35% Dev.	60.24%	47.19%	38.27%	35.42%
40% Dev.	59.34%	45.93%	36.40%	33.11%
45% Dev.	58.56%	44.96%	35.14%	31.47%
50% Dev.	57.66%	43.82%	33.70%	29.98%

Generally, the ratios decrease as the *MaxBlendCandles* and *GapParam* parameters increase since the number of blended candlestick increases. There are several similar ratios in Table II. The ration of approximately 50% is found for the two pairs of parameters, i.e., the *MaxBlendCandles* of 7 with the *GapParam* of average plus "1% Dev." and the *MaxBlendCandles* of 3 with the *GapParam* of average plus "25% Dev."

Fig. 7 shows the original candlestick chart of the Nikkei stock average from Feb. 15 to July 20, 2018 annotated by 5-day and 25-day moving averages. Fig. 8 and Fig. 9 show the two blended candlestick charts with the compression ratio of approximately 50%.

Compared to the original chart, the two blended candlestick charts simply reveal trends of price movements by eliminating noisy candlesticks that are generated during the period of market's indecisiveness.

Figure 7. Original candlestick chart of Nikkei 225 average annotated by 5-day and 25-day moving averages

Figure 8. Blended candlestick chart
(*MaxBlendCandles* is three; *GapParam* is 25% deviation)

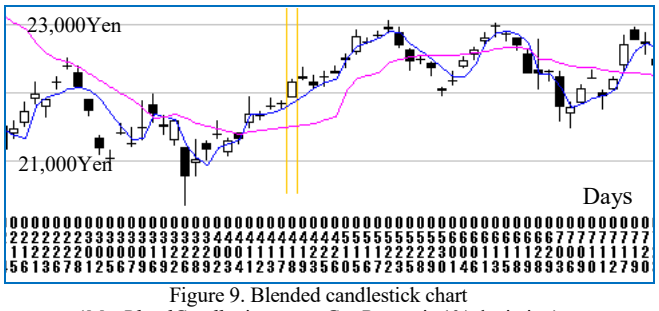

Figure 9. Blended candlestick chart
(*MaxBlendCandles* is seven; *GapParam* is 1% deviation)

Fig. 10 shows a frequency diagram representing price change distributions of the blended candlesticks shown in Fig. 8.

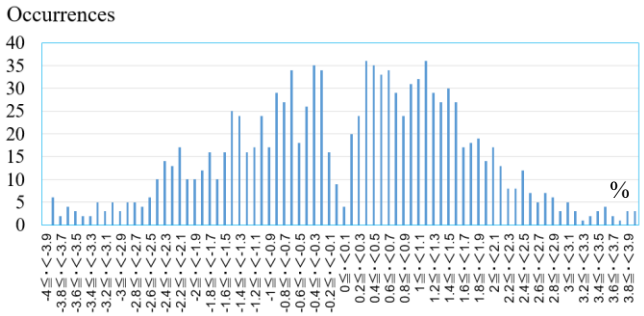

Figure 10. Frequency diagram of change distributions

The frequency diagram is in the form of a normal distribution with a collapsed center that is generated by the blending process. The average of price change is 0.0513% and the deviation is 1.815%. The deviation increase about 13.4% through the blending process.

V. Blended Chandlestick Charts for Prediction

An algorithm for retrieving similar candlestick chart is proposed. The predictabilities of a "bounce pattern" is evaluated through experiments using a blended candlestick chart of the Nikkei stock average.

A. Pattern Indicating Steady Uptrend

Estimating the predictabilities of a candlestick chart pattern is a major concern among researchers of this field. Through experiments of chart patterns, we focus on a "bounce pattern" to the 5-day average price lines.

In the Nikkei stock average, the pattern seems to rise on April 18, 2018, labeled by "0418," as shown in Fig. 7 annotated with yellow lines. However, several days are needed to conform the pattern because candlesticks showing indecision follow after the the day. The blending algorithm works to spot the fact clearly on the chart shown in Fig. 8. The three candlesticks from April 19 to April 23 in Fig. 7 are blended into one medium-length body candlestick labeled by "0423" with a rather long upper shadow shown in Fig. 8.

B. Retrieving Similar Chandlestick Charts

The proposed blending algorithm eliminates noisy candlesticks, which makes an algorithm to retrieve similar candlestick charts simple. Let OpenP[0], CloseP[0], 5AvP[0], and 25AvP[0] denote an open price, a close price, a 5-day moving average, and a 25-day moving average of a considering business date, respectively. Let the previous day is indexed "-1," and the day before the previous day is indexed "-2," etc. Let the parameters TH, TH5Av and TH5Av define the thresholds for retrieval.

For a given business date j in the period *Period* that defines the number of candlesticks, i.e., $0 \geq j > -Period$, the business date x ($0 \geq x$) that has similar stock prices to those of date j is identified if and only if the following conditions are satisfied:

(a) $|\ \mathrm{CloseP}[j] - \mathrm{CloseP}[x+j]\ | < \mathrm{TH}$,
(b) $|\ 5\mathrm{AvP}[j] - 5\mathrm{AvP}[x+j]\ | < \mathrm{TH5Av}$,
(c) $|\ 25\mathrm{AvP}[j] - 25\mathrm{AvP}[x+j]\ | < \mathrm{TH25Av}$,
(d) Body color of the first day is the same as that of the similar candlestick chart, i.e., $(\mathrm{CloseP}[0] - \mathrm{OpenP}[0]) * (\mathrm{CloseP}[x] - \mathrm{OpenP}[x]) > 0$,

Table III shows the number of retrieved business dates performed on the blended candlesticks shown in Fig. 8 with April 18, 2018 as a key date and with the *Period* of three. The threshold TH varies from 0.4% to 0.85%. TH5Av and TH25Av are set to TH/√5 and TH/√25 which are the 5-day and 25-day standard deviation of the sample [2], respectively.

TABLE III. NUMBER OF retrieved charts for threshold TH

TH (%)	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85
No. dates	3	4	7	11	14	19	21	24	26	30

The retrieved results are a list of business dates. The list shown below is the result of the retrieval with the threshold TH of 0.55%.

20171013, 20161215, 20151106, 20151030,
20150320, 20150218, 20121203, 20121122,
20110629, 20100401, 20080421

Each element indicates the business date in the YYYYMMDD format.

C. *Evaluating Predictability of Trends*

Fig. 11 shows an overlapped graph of the closing price sequences in percentage that are retrieved when the threshold TH is 0.55%. All retrieved dates are aligned on the origin to make the comparison easy. Eight out of eleven closing price sequences suggest uptrends, while the other three sequences show slight downtrends. The average of these price sequences, shown in thick light blue line, depicts a steady uptrend. The business days in Fig. 11 are those of the blended candlestick charts.

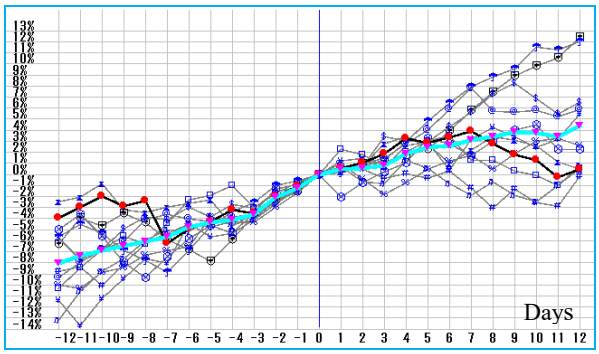

Figure 11. Overlaid closing prices on blended candlestick chart

Table IV shows statistics, i.e., average, deviation, prediction intervals, maximum and minimum of price prediction concerning 21 retrieved price sequences, which is the result of the retrieval with the parameter TH of 0.55%.

TABLE IV. AVERAGE, DEVIATION, PREDICTION INTERVAL , MAXIMUM AND MINIMUM OF PRICE PREDICTION CONCERNING 21 RETRIEVED PRICE SEQUENCES THAT ARE RETRIEVED WITH PARAMETER TH OF 055%.

	1	2	3	4	5	6	7	8	9	10
Av (Average)	0.45	0.57	0.85	1.94	2.45	2.67	3.16	3.37	3.61	3.53
Dev (Deviation)	0.95	0.77	1.40	1.28	1.45	2.20	3.06	3.40	3.67	4.22
Av + Dev/√11	0.74	0.81	1.28	2.32	2.89	3.33	4.08	4.40	4.72	4.80
Av − Dev/√11	0.17	0.34	0.43	1.55	2.01	2.01	2.24	2.35	2.51	2.26
Av + Dev*1.96/√11	1.01	1.03	1.68	2.69	3.31	3.97	4.97	5.38	5.78	6.02
Av − Dev*1.96/√11	-0.11	0.12	0.03	1.18	1.59	1.37	1.35	1.37	1.45	1.03
Maximum	2.24	1.73	3.36	3.44	4.83	6.42	7.91	8.81	9.51	11.47
Minimum	-2.10	-0.79	-1.80	-0.80	-0.35	-0.88	-1.94	-3.07	-1.94	-2.60

Since the average and the deviation of 11 retrieved prices are known for each day, a prediction interval [ℓ, u] is calculated by the following formula:

$$[\ell, u] = [Av - \alpha * Dev/\sqrt{N}, Av + \alpha * Dev/\sqrt{N}] \quad (6)$$

α is set to 1.0 and 1.96 to calculate the 68.26% and 95% prediction intervals. N is the number of retrieved prices and is 11 in this case. The statistics speculates that the stock price increase up to 3.53% on average with the standard deviation of 4.42% in the coming ten blended days. The 68.26% prediction interval is expected between 0.17% and 4.80%, while the minimum and maximum interval is likely between −3.07% and 11.47%.

Fig. 12 depicts average prices of the business dates shown in Table III. The horizontal line of Fig. 12 shows the business days on the blended candlestick charts. The statistics of the experimental results seem to assure a trader that the "bounce pattern" to the 5-day average price line is a promised uptrend pattern which would continue for coming several business days.

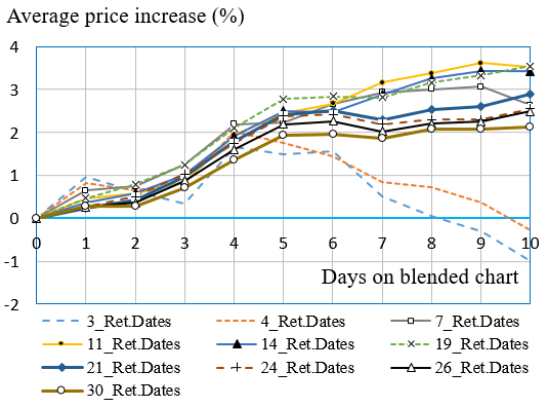

Figure 12. Average prices of retrieved price sequences

D. *Time Analysis*

The blending algorithm is implemented using a common function that transforms a CSV file saving stock price data into internal structures. The CSV file is downloaded from Web sites providing historical stock price data [14] - [16].

The performance of the blending algorithm is measured for historical data of three markets, i.e., the Dow Jones Industrial Average (DJIA) [15], the Nasdaq Composite Index (NASDAC) [16], and the Nikkei-225 stock average (Nikkei 225) [14].

The period of collected data is 5 years, 10 years, 15 years, 20 years, and 25 years from November 13, 2018 as the latest business day. The number of stock data records are 1,260 for 5 years, 2,518 for 10 years, 3,777 for 15 years, 5,033 for 20 years, and 6,296 for 25 years.

Fig.13 shows the elapsed times in milliseconds for CSV file processing (dashed lines) and for the chart blending (solid lines). The values in Fig.13 are the average value of five measurements.

The elapsed times to process the CSV files shown in dashed lines are almost proportional to the number of data records. The measurement errors are within 70 milliseconds. The times to blend candlesticks shown in solid lines are also proportional to the number of blended candlesticks, e.g., 4,111 for DJIA, 3,581 for NASDAC, and 3,353 for Nikkei 225 on data records for 25 years.

We performed the experiments using the following PC environment:

CPU: Intel Core i7-6700 (3.40 GHz)
Main memory: 8 GB
OS: Windows 10 HOME 64 Bit
Programming Language: Java 1.8.0_101.

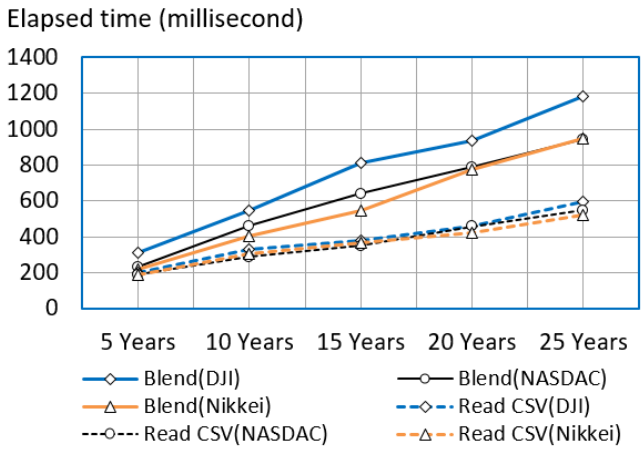

Figure 13. Elapsed time for processing CSV file and for blending candlestick

VI. Conclusion and Future Work

Predicting short-term stock price trends is of great interest among traders because successful prediction of stock prices may promise attractive benefits. The candlestick chart patterns usually consisting of less than five candlesticks are popular worldwide among swing traders due to its convenience. Despite of its popularity, the effectiveness concerning predictability on future price trends is still controversial issues.

In this study, we focus on the fact that the stock price does not show clear trend during the periods when there is no significant news on economics and/or politics. A blending algorithm is developed to transform candlesticks sharing some specified price ranges into one candlestick. This transformation enables human traders to identify price trends easy, and allows programmers to implement retrieval algorithm simple.

We propose a new "bounce pattern" against 5-day average, and perform experiments on the pattern using blended candlestick charts. The results show that the blended candlesticks are effective for short-term stock price predictions. The elapsed times of the proposed blending algorithm are measured using three major stock markets. The results show that the proposed algorithm runs in proportion to the number of stock price data records.

As for the future work, we are planning to apply the blending algorithm to international stock indexes, such as S&P500 and Nasdaq, and individual stocks for practical stock trading.

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