1. INTRODUCTION

This paper proposes an interactive context search system for supporting exploratory analysis of exchange rate data. Various kinds of trend information are recently available on the Web, such as stock price, exchange rate, and cabinet approval rating. In particular, trend information about financial markets is widely used by companies, organizations, and individuals as one of important resources for their decision making. As a result, trend information affects economic activities in the real world. For example, companies exporting products make decision on their business investments based on exchange rate. On the other hand, various events in the real world affect the fluctuation of exchange rate. Therefore, analyzing complicated relationships between trend in financial markets and events in the real world based on information collected from the Web has become one of hot research topics [1, 2].

Although most of such researches focus on the analysis based on computation, such as multi-agent simulation, the aim of this paper is to support humans to understand complicated relationship between trend in financial markets and events in the real world through exploratory data analysis (EDA) [3-5]. Target data of this paper is exchange rate data. It is expected that the support of EDA for such data is not only useful for experienced foreign exchange traders, but also for beginners as well as for educational purpose.

In order to understand relationship between fluctuations of exchange rate and events in the real world, it is required to retrieve related data in the other resource. For example, if we want to know the events happened when dollar-yen exchange rate drastically increases within a few days, we will retrieve events occurred within the corresponding time period. On the other hand, if we want to know how dollar-yen rate will tend to change when the Bank of Japan (BOJ) intervenes in the market, we will examine past exchange rate data of the periods when the BOJ actually intervened. Therefore, bidirectional search function should be provided for supporting EDA of exchange rate data.

This paper defines the context of an item as the information that can be a clue to understand its value and characteristics. According to this definition, fluctuation of exchange rate is the context of an event, and vice versa. As both of the contexts is important for analyzing exchange rate data, this paper proposes two types of context search functions. One is summarizing events occurred in similar time periods, and another is searching events along with corresponding time periods.

One of major contributions of this paper is to select similarity calculation for temporal data based on analysis purpose. It is known that similarity among objects is affected by frame of reference [6]. Fluctuation of exchange rate data has various levels of granularity, such as daily, weekly, and monthly change, among which analysts are
supposed to select a suitable one based on their analysis purpose. Such granularities can be regarded as a kind of frame of reference, which affects their similarity judgment. In order to introduce such user-dependent factors in similarity judgment of temporal data, this paper employs the approach of Kansei Engineering. That is, this paper examines several similarity calculations for searching similar time periods. Experiments are conducted for revealing similarity calculation that is suitable for different levels of granularity. Based on this result, the proposed support system automatically selects similarity calculation, which is determined by the length of time period specified as a query. The idea behind this is that the length of query period supposes to reflect users’ analysis purpose.

Prototype system is implemented based on the proposed context search, of which effectiveness is also shown with experiments with test participants.

2. RELATED WORKS

2.1 Trend Information

As the growth of data resources that accumulate data continuously, trend information is becoming popular. A trend generally means a general direction in which a situation is changing / developing. The MuST (Multimodal Summarization for Trend information) workshop extends the general meaning and defines trend information as “a kind of summarization of temporal statistical data, obtained through synthesis rather than simple enumeration.” [7]

Examples of trend information are movements of gasoline price, approval rating for the cabinet, natural disasters such as typhoon and earthquakes, and hot topics in blogs. Trend information becomes one of the most important information available on the Web, which is crucial for our decision-making and future prediction.

Various technologies have been studied for utilizing trend information. One of major approaches is to summarize trend information. Kobayashi et al. [8] have proposed to generate a verbal report on the trends of stock price from the behavior of 2D charts. The shape of a chart is recognized with least square and expressed with words that often appear in news articles reporting the trends of stock prices.

Visualization techniques are often applied to show the trend information in understandable manner. Visualization techniques specific to a certain type of data are also used in various domains, of which typical example is candle chart, which is applied to exchange rate data and stock price data. Some methods try to visualize the trend in qualitative manner. The STEND [9] draws annotations such as arrows on a chart, which qualitatively express temporal trend of the chart, including uptrend, downtrend and peak. These annotations are generated based on the qualitative expression in news articles.

When understanding trend information, it is important to know the relationship between trends and events that might be its cause. The Trend Viewer [10] focuses on point of interests on trend data, such as the point when values drastically change, or those when the maximum / minimum value are observed. It also analyzes the corresponding news articles, and provides keywords which may affect such changes.

2.2 Analysis of Financial Markets

Data in financial markets is one of typical and important trend information, and various analysis methods have been studied. Well-known and widely-used approaches are fundamental analysis and technical analysis [11, 12]. The former approach focuses on economic fundamentals such as economic growth, prices, and balance of payments. On the other hand, technical analysis predicts future trends based on the analysis of temporal patterns of target trend data. These two approaches are complementary to each other.

Traders in financial markets make use of various information in order to analyze and predict trends of the market. Documents including news articles and reports are important resources for obtaining various information that may affect market trends.

Izumi et al. have proposed a text-mining method for long-term market analysis [1]. The method extracts feature vectors from monthly reports of Bank of Japan, based on which trends of markets are estimated by regression analysis. Agent simulation has been also applied to market analysis [2, 13-15]. The SEMAS (Socially Embedded Multi Agent Simulation) approach integrates an artificial market and text mining technology [2]. This approach extracts economic trends from text data circulating in the real world, and inputs it into market simulation.

2.3 Distance / Similarity Measures for Temporal Data

As noted in Section 1, one of the main contributions of this paper is to reveal similarity (distance) calculation of temporal data, which are suitable for different levels of granularity. Various similarity/distance measures have been proposed for temporal data [16], among which popular ones are Euclidean distance measure and dynamic time warping (DTW) distance.
The Euclidean distance measure is defined by (1), where \( x \) and \( y \) are \( N \)-dimensional vector of temporal data. Each dimension of a vector corresponds to a data point.

\[
d_E(x, y) = \sqrt{\sum_{i=1}^{N} (x_i - y_i)^2}
\]

The Euclidean distance can be used when the length (dimension) of two temporal data is the same. On the other hand, the DTW can be applied for calculating distance between temporal data having different length. The DTW calculates the best matching between two data based on dynamic programming.

3. INTERACTIVE CONTEXT SEARCH SYSTEM

3.1 Outline of System

This paper proposes an interactive context search system for exchange rate data, which supports users to grasp the relationship between exchange rate and events. Figure 1 shows the screenshot of a prototype system. The system is implemented with using JavaScript. It consists of 4 panels. The left-middle part is a graph drawing panel, which shows exchange rate data of time period specified by a user. The granularity, i.e., the range of horizontal axis is adjusted automatically based on the length of time period to be visualized. The left-lower part is a graph overview panel, which shows the graph of entire data. The left-upper part is an event timeline panel, which shows the headlines of news articles issued within the time period displayed on the graph drawing panel. Its enlarged screenshot is shown in Fig. 2. This panel is synchronized with the graph drawing panel, i.e., a data point and a headlines displayed in the same horizontal position correspond to the same day. In this panel, the type of an event is recognized by color as specified in Sec. 3.2.

The right-hand part is a control panel, which is used to zoom in/out the graph drawing panel and to conduct context search.

3.2 Target Data

The proposed system uses two types of data: dollar-yen rate data and event data. A daily data of dollar-yen rate is collected from OANDA. As for event data, headline data of Yahoo! Japan is collected using API. The range of collected data is from January 1, 2007 to December 29, 2012.

Among the collected headlines, those containing words related with fluctuation of exchange rate as shown in Table 1 are extracted and used in the system. It is noted that the words in the table are translated from Japanese, as Japanese headlines are used by the prototype system. The headlines are classified into the following 6 types, to each of which following colors are assigned in the event timeline panel. Note that different color assignment was also used in the experiments of Sec. 4.2 for examining the influence of color assignment on users’ exploration.

- Red: Events related with US economy
- Blue: Events related with Japanese economy
- Green: Events related with European economy
- Pink: Events in US (other than economy)
- Light blue: Events in Japan (other than economy)
- Light green: Events in Europe (other than economy)

\[\text{Table 1: Related words with fluctuation of exchange rate.}\]

<table>
<thead>
<tr>
<th>Category</th>
<th>Subcategory</th>
<th>Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>Event</td>
<td>Economy</td>
<td>Economic climate, crude, employment, jobless rate, interest rates, economy, prices, stock prices, currency exchange, securities, finance, bank, claim, market rate, balance of payment, trading</td>
</tr>
<tr>
<td></td>
<td>Politics</td>
<td>Politics, statements, policy, institution, political situation, foreign diplomacy, foreign exchange intervention, bill</td>
</tr>
<tr>
<td></td>
<td>War/Terror</td>
<td>Terror, earthquake, earthquake disaster, damage</td>
</tr>
<tr>
<td></td>
<td>Disaster</td>
<td></td>
</tr>
<tr>
<td>Country</td>
<td>USA</td>
<td>America, USA, NY, dollar</td>
</tr>
<tr>
<td></td>
<td>Europe</td>
<td>Europe, Euro</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>International, world</td>
</tr>
</tbody>
</table>

1 OANDA: http://www.oanda.com/
3.3 Interaction

Using the prototype system, a user is supposed to analyze the fluctuation of exchange rate by examining the relationship between exchange rate data and events in the real world interactively. Therefore, the system provides various interactive functions.

Figure 3 shows the zooming function of exchange rate data. A user can zoom in by selecting time period with a mouse on the graph drawing panel (denoted as pink color in left of Fig. 3), and click zoom-in button on the control panel. Zoom-out button is also on the control panel.

Events (headlines) displayed on the event timeline panel can be filtered out by specifying a word to be contained on the control panel as shown in Fig. 4. By using this function, a user can search events with specified type and examine the corresponding fluctuation of exchange rate data. Therefore, it is regarded as a context search, in which fluctuation of exchange rate is the context of an event.

The system also provides a function for searching time periods having similar trends (Fig. 5 and Fig. 6). By selecting a time period as a query on the graph drawing panel (left in Fig. 5) and pushing search button on the control panel, similar time periods are retrieved. The retrieved periods are highlighted in the graph drawing panel as shown in the right of Fig. 5. Details of retrieved results are shown below the interface, which can be accessed with using a scroll bar. Fig. 6 shows the details of retrieved results, in which an event timeline and exchange rate are displayed for a query and each of retrieved time periods.

The summary of retrieved result is also provided as a set of related words, which is shown in the right-upper part of

![Figure 3](zooming_graph.png)  
**Figure 3**: Zooming in a graph.

![Figure 4](filter_headlines.png)  
**Figure 4**: Filtering of headlines.

![Figure 5](search_similar_periods.png)  
**Figure 5**: Search of time periods having similar trends.

![Figure 6](search_result.png)  
**Figure 6**: Search result of similar periods.

![Figure 7](enlarged_event_summary.png)  
**Figure 7**: Enlarged screenshot of event summary.
to occur when a trend of interest happened. In particular, by providing related words by dividing into 3 sub-periods, a user can examine events occurred in the beginning of target fluctuation and those at the end, separately.

3.4 Retrieval of Similar Time Periods

When searching similar time periods, this paper automatically selects suitable distance measure according to the granularity (i.e., daily, weekly, and monthly) of interest. In addition to existing distance measures as introduced in Sec. 2.3, this paper employs a distance measure based on regression lines. Given temporal data \( x \) and \( y \), the distance is calculated by the following procedure.

1. Divide \( x \) into \( t \) segments.
2. Obtain \( n \)-dimensional vector \( x' = (x_1', \ldots, x_t') \), in which \( x'_i \) is the slope of a regression line of the \( i \)th segment.
3. Obtain \( y' \) in the same way as \( x' \).
4. Calculate the Euclidean distance between \( x' \) and \( y' \).

4. EXPERIMENTAL RESULTS

Two kinds of experiments are conducted. The aim of the first experiment is to examine distance measures suitable for different levels of granularity. The second one is conducted to examine the effectiveness of the proposed system for interactively analyzing exchange rate data.

4.1 Experiment on Similarity Calculation of Temporal Data with Different Granularities

Twelve graduate / undergraduate students in Engineering took part in this experiment. They were asked to evaluate the similarity of presented time periods to a query time period from the following viewpoints. The similarity is judged with 6-point scale, 1: very similar to 6: completely dissimilar.

- Overall shape.
- Fluctuation range.
- Points when typical fluctuation occurred.

In order to examine similarities of several granularities, 3 queries of which range is different were prepared as shown in Table 2. The actual time periods are also shown within brackets in “Range” column. In the experiments, not only time periods of high similarity, but various levels of similar periods were also presented to the test participants. The ranks of the presented time periods are shown in “Presented ranks” column. Five time periods are selected from higher, middle, and lower ranks respectively. It is noted that the total number of time periods, as shown in “Lowest” column is different according to the length of a query time period. That is, the longer a query is, the less the total number of time periods is. It is because this paper searches similar time periods so that those are not overlapped with each other. We do not search overlapped time periods in order to provide a user with various time periods spreading over temporal axis. As the proposed system is designed to be used interactively, each of retrieved time periods is expected to be used as the starting point of user’s exploratory data analysis. Therefore, a retrieved result should contain various time periods, each of which has similar temporal fluctuation with a query and spreads over temporal axis. By avoiding the situations where almost similar time periods occupy a retrieved result, we do not allow a retrieved time period to overlap with other retrieved periods.

This paper compares the following 4 measures.

- Euclidean distance
- DTW
- Segmentation-based measure (5 segments)
- Segmentation-based measure (10 segments)

The segmentation-based measure refers to what is introduced in Sec. 3.4. When applying Euclidean distance and DTW, original vector \( x \) is converted into the \( n-1 \) dimensional vector as shown in (3), in order to eliminate the difference of absolute values. Segment-based measure does not require this conversion because it ignores intercept of a regression line.

\[
x'_{\text{diff}} = (x_2 - x_1, x_3 - x_2, \ldots, x_n - x_{n-1})^T.
\] (3)

Table 3 shows correlation coefficient between the values of distance measures and average evaluation by test

Table 2: Summary of used queries.

<table>
<thead>
<tr>
<th>Query</th>
<th>Range</th>
<th>Presented ranks</th>
<th>Lowest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>2weeks (7/25-8/7, 2011)</td>
<td>1-5, 98-102, 196-200</td>
<td>200</td>
</tr>
<tr>
<td>Q2</td>
<td>3months (9/1-12/1, 2008)</td>
<td>1-5, 13-17, 26-30</td>
<td>30</td>
</tr>
<tr>
<td>Q3</td>
<td>6months (4/1-10/1, 2007)</td>
<td>1-5, 6-10, 11-15</td>
<td>15</td>
</tr>
</tbody>
</table>

Table 3: Comparison between distance measures and human judgment.

<table>
<thead>
<tr>
<th>Query</th>
<th>Euclidean</th>
<th>DTW</th>
<th>5 Segments</th>
<th>10 Segments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>0.81</td>
<td>0.79</td>
<td>0.73</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>3.42</td>
<td>3.82</td>
<td>3.37</td>
<td>3.17</td>
</tr>
<tr>
<td>Q2</td>
<td>-0.07</td>
<td>0.38</td>
<td>0.30</td>
<td>0.63</td>
</tr>
<tr>
<td></td>
<td>4.95</td>
<td>4.37</td>
<td>3.95</td>
<td>3.77</td>
</tr>
<tr>
<td>Q3</td>
<td>-0.38</td>
<td>0.02</td>
<td><strong>0.45</strong></td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>5.35</td>
<td>4.27</td>
<td><strong>3.35</strong></td>
<td>3.70</td>
</tr>
</tbody>
</table>
participants, as well as their average evaluation of time periods in top 5 ranks. In the table, values shown in upper cell are correlation coefficient, and those in lower cell are average evaluation.

In the case of Q1, all of 4 measures correlate with human evaluation. In particular, Euclidean measure and DTW have stronger correlation than others. As the average evaluation of top 5 retrieved results of Euclidean measure is better than DTW, Euclidean measure is regarded as the most suitable measure for short time period (2 weeks in this experiment). As the number of points in a query and retrieved time periods in Q1 is much smaller than those in Q2 and Q3, Euclid distance, which accumulates difference in each data point, can capture detailed characteristics of fluctuation compared with other measures. Figure 8 shows exchange rate data of a query and some of retrieved time periods for Q1 by using Euclidean measure. In the figure, time periods of 1st, midst (100th), and the lowest rank (200th) are shown, respectively. The figure shows the retrieved time period becomes dissimilar with a query as it goes down in the rankings.

As for Q2, only 10 segments has correlation with human evaluation. As its average evaluation of top 5 retrieved results is also the best among 4 measures, 10 segmentation-based measure is regarded as the most suitable measure for medium-term time periods (3 months). Figure 9 shows a query and some of retrieved results for Q2 by using 10 segmentation-based measure. Characteristic fluctuation of a query is downtrend, which is hold in the 1st retrieved result and gradually lost in lower ranks.

The result of Q3 shows none of 4 methods have correlation with human evaluation, except that 5 segmentation-based measure has a weak correlation. As its average evaluation of top 5 retrieved results is good compared with the results of Q1 and Q2, 5 segmentation-based measure is regarded as the most suitable measure for long-term time periods (6 months). Figure 10 shows a query and some of retrieved results for Q3 by using 5 segmentation-based measure. It shows the retrieved time period becomes dissimilar with a query as it goes down in the rankings.

Compared with Q1, target time periods of Q2 and Q3 contain quite a few data points. The results that segmentation-based measures obtained better results than Euclidean measure for Q2 and Q3 indicate that test participants focused on the outline of fluctuation and paid less attention to details. As mentioned above, Euclidean distance is suitable for shorter time period, in which a user is interested in detailed characteristics of fluctuation. On the other hand, segmentation-based measures is suitable for
longer time period, in which a user is interested in outline of fluctuation.

Regarding results for longer time period, time periods in Q3 (6 months) is twice as long as Q2 (3 months), and 10 segmentation-based measure consists of twice as many segments as 5 segmentation-based measure. That is, there is correspondence between length of time period and the number of segments of suitable distance measure. One of possible interpretations is that test participants employed the same level of granularity for judging similarity for Q2 and Q3. Although further study will be required, the number of segment could be determined based on the length of target time periods.

4.2 Experiment on Data Analysis by Test Participants

In order to evaluate the effectiveness of the proposed context search, experiments with test participants were conducted. Ten graduate / undergraduate students in Engineering were asked to perform two kinds of tasks with using the proposed system. One of the tasks is to answer what they think is the cause of given fluctuation. Another task is to predict future trend of exchange fluctuation. Note that the focus of evaluation is not on how accurate participants could answer the questions, but on how the proposed system could support their exploratory analysis. The procedure of experiments is as follows.

1. Answer questionnaire about knowledge of currency exchange.
2. Use the system for getting used to it.
3. Perform 4 tasks of guessing the cause of given fluctuations.
4. Perform the task of predicting future trend.
5. Answer questionnaire about knowledge of currency exchange.

A participant spent about 10 minutes in total for step 1 and 2, about 60 minutes in total for step 3 and 4, and about 10 minutes for step 5.

In the questionnaire of step 1, we asked the frequency of checking exchange rate data in their daily lives. The result shows that 6 among 10 participants do not check exchange rate at all, 1 participant rarely checks it, and 2 participants check it once per week. In step 1 and 5, we also asked the participants the factors which they think would cause the exchange fluctuation. It is observed that 8 among 10 participants answered more factors at step 5 than step 1.

In step 3, exchange rate of a certain time period is given to a participant, from which s/he was asked to answer the cause of the fluctuation. Figures 11-14 show the target time periods, each of which corresponds to different levels of granularity. Figure 11 shows fluctuation within a week, which was actually caused by exchange intervention by Japanese government. Figure 12 shows a 10-yen appreciation against the dollar within about 2 months, which was caused by subprime mortgage crisis in the US. While those fluctuations had obvious causes, fluctuations as shown in Fig. 13 and 14 had no such well-known cause. Figure 13 shows a 6-yen appreciation against the dollar within 12 days, and Fig. 14 shows 10-yen depreciation within around 3 months.

For the question regarding Fig. 11, 3 participants could answer correctly, among them 2 participants knew the event itself beforehand. For the question regarding Fig. 12, 5 participants could answer correctly, among them 2 participants knew the event beforehand. Note that they had to find the relationship between the event and given time period even though they knew the event beforehand. For the question regarding Fig. 13, which had no obvious cause as mentioned above, the US presidential

Figure 11: Fluctuation from July 31 to Aug. 6 in 2011.

Figure 12: Fluctuation from Sep. 2008 to Nov. 2008.

Figure 13: Fluctuation from March 7 to March 18 in 2008.

Figure 14: Fluctuation from Dec. 2008 to March 2009.
election was the most common answers. Five participants mentioned it as the cause of the fluctuation. For the question of Fig. 14, there were two typical answers: 3 participants mentioned Japan-US relations, and other 3 participants mentioned employment issue.

When participants tried to find the cause of a given fluctuation, most of them followed the following behaviors.

(1) Examine the given period by zoom-in operation.
(2) Find some keywords from headlines within the period.
(3) Retrieve similar time periods with the period.
(4) Find some keywords from the event summary of the retrieved result.
(5) Filter out headlines by specifying keywords found in step (2) and (4) for examining the relationship between temporal trend and events related with the keywords.

This behaviors show the participants completed the task by utilizing functions provided by the proposed system. When they found keywords of interest in step (2) and (4), presence of a keyword on the space of visualizing headlines affected their keyword selection. The main factors affecting the presence of a keyword on the space are color and frequency. In the case of questions regarding Fig. 11 and 14, color is supposed to affect the participants’ answers. In the experiment, events related with US were displayed with red and pink for 5 participants, while events of Japan were displayed with red and pink for other 5 participants. For the question of Fig. 11, all 3 participants who answered correctly used the settings in which events of Japanese economy was displayed with red. For the question of Fig. 14, 3 participants who mentioned Japan-US relationship as the cause used the setting in which red color was assigned to events of Japanese economy. As red and pink keywords are more visible than blue and green keywords, participants tended to focus on the keywords of such colors.

In the case of Fig. 12 and 13, many news articles related with financial crisis and US presidential election, respectively, which tended to attract participants’ attention.

Even though color and frequencies of keywords would be clues for the participants to focus on keywords in addition to their prior knowledge, they carefully examined the relation between the keyword they focused on and temporal trend as mentioned above. Considering this result and the above-mentioned result that 8 participants answered more factors at step 5 than step 1, it can be said that non-expert users could improve their understanding about relationship between exchange rate and events through interactive data analysis with using the proposed system.

For the task of predicting future trend, a participant was asked to predict exchange rate of tomorrow, a week later, a month later, and 6 months later, respectively. The answer was given as either of low / high / almost the same. The reasons of the prediction were also answered with free description.

The aim of this task is not to evaluate their prediction accuracy, but to examine strategies employed by test participants using the proposed system. It was observed that their strategies were roughly divided into the following 3 types.

(A) Predict based on recent events / fluctuation.
(B) Find past time periods / event similar to recent fluctuation / events, and predict based on the trend after such similar periods.
(C) Predict based on graphical pattern of fluctuation.

Table 4 shows the number of participants who mainly used each strategy. Note that one participant could not predict for tomorrow, and 2 participants could not predict for 6 months later. Table 4 shows strategy (A) was mostly used among 3 strategies. However, the number of participants who used strategy (B) increased for longer-term prediction. As it is difficult to predict how long recent events would have effect on exchange rate, it is supposed that test participants had to refer to the past similar trends. This result shows the participants could perform various types of exploratory analysis depending on the task by using the proposed system.

The test participants were also asked to answer the questionnaire about the usability of the proposed system. Positive comments are as follows. The number of participants who made a comment is written in the parentheses.

- The user interface and operations are intuitive and easy to understand. (4)
- The function for searching time periods having similar trends is convenient. (3)
- Visualizing headlines on timeline is useful for understanding fluctuation of exchange rate. (2)

Table 4: Categorization of used strategies in prediction task.

<table>
<thead>
<tr>
<th>Question</th>
<th>(A)</th>
<th>(B)</th>
<th>(C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomorrow</td>
<td>5</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>1 Week</td>
<td>5</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>1 Month</td>
<td>3</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>6 Months</td>
<td>3</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>
• Factors common to many patterns (temporal fluctuations) could be found by using event filtering function. (1)
• Showing keywords as the summary of retrieved result is useful. (1)
• Using the function of searching time periods and event filtering function alternatively can broaden search space. (1)

These comments show user interface and both of context search functions could obtain positive feedback. On the other hand, negative comments and suggestion for improvement are as follows.
• Quality of the summary of retrieved result could be improved. (2)
• Only the headline without contents of an article is not enough. (1)
• I could not understand the meanings of technical terms in headlines. (1)
• There were small number of headlines about what I wanted to know. (1)
• When zooming in a certain time period, outline of long-term fluctuation tends to be lost. (1)
• A function for searching time periods by specifying date could be useful. (1)
• Font size is too small. (1)
• Accessing retrieved result with scroll bar (mouse wheel) is inconvenient. (1)

Some of those comments such as about font size could be solved with minor modifications. Major modifications to be considered in our future work are enrichment of resources about related news articles and improvement of keyword extraction for the summary of retrieved result.

5. CONCLUSIONS

This paper proposes an interactive context search system for supporting exploratory analysis of exchange rate data. The prototype system selects suitable distance measures for finding similar time periods according to the granularity, which is examined with experiments. Experimental results also show the participants could analyze relationship between exchange rate and events through the process of exploratory analysis with using the proposed system. Future works include further experiments with test participants using more analysis tasks and improvement of the proposed system based on feedbacks from the test participants. We think a context search is essential function to support EDA for analyzing data space consisting of multiple resources.

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