The Fish-eye Visualization of Foreign Currency Exchange Data Streams

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Abstract

In a foreign currency exchange market, there are high-density data streams. The present approaches for visualization of this type of data cannot show us a figure with targeted both local details and global trend information. In this paper, on the basis of features and attributes of foreign currency exchange trading streams, we discuss and compare multiple approaches including interactive zooming, multiform sampling with combination of attribute of large foreign currency exchange data, and fish-eye view embedded visualization for visual display of high-density foreign currency exchange transactions. By comparison, Fish-eye-based visualization is the best option, which can display regional records in details without losing global movement trend in the market in a limited display window. We used Fish-eye technology for output visualization of foreign currency exchange trading strategies in our trading support system linking to real-time foreign currency market closing data.

Keywords: Large database visualization; Fish-eye view; Local details; Global trends

1 Introduction

In foreign currency exchange data stream, the number of real-time transactions is normally very large and distributed in high-density, for instance, more than 20,000 records in a day in Australian Foreign currency exchange. However, the width of display window is limited, usually from 800 to 1024 or so. So, it is necessary for us to decide how to distribute so many points into a very small limited window efficiently and effectively on a very density graph (TRADESTATION, F-TRADE).

For instance, brokers and retailers are interested in browsing the price movement trend in a long-term period (as shown in Figure 1, which shows about 99,990 trading transactions from 1 January 1996 to 31 September 2004 in foreign currency exchange. The width of the window is 640, so in each unit there are at least about 15

transactions inside). However, they also want to watch what has happened in details on some specific time points (Jiawei, 2002).
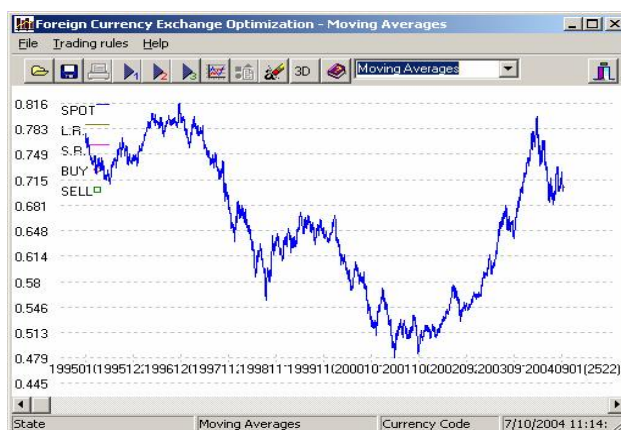

Figure 1 High-density foreign currency exchange data stream (x-coordinate is the order number of trades).

In these cases, it is helpful for traders to make decisions with visual display both of details of DP and global information including SP. However, in all existing foreign currency exchange trading systems and back-testing systems as we know, there are no mechanisms or facilities for showing the above two types of information in a same window at the same time.

In this paper, based on our experience in building infrastructure for foreign currency exchange Trading Rules Automated Development and Evaluation (F-TRADE (F-TRADE), a foreign currency exchange trading/back-testing system, we build in a project of Capital Markets CRC) (CMCRC) by connectivity to realistic foreign currency exchange data, we study multiple strategies for online visualization of heavy density foreign currency exchange trading transactions (Sullivan, Allan 1999, Kin, K.C. 2000). These approaches include interactive zooming, multiform sampling with combinations of different features and attributes of large foreign currency exchange data, and fish-eye-based visual output. From the viewpoint of displaying both local details and global trends of foreign currency exchange transaction stream, fish-eye-based interactive visualization is more powerful and suitable for high-density foreign currency exchange stream in the realistic applications.

This paper is organized as follows. Interactive zooming is introduced briefly in Section 2. In Section 3, 4 and 5, we present three sampling visualization approaches with combinations of value and features of foreign currency

exchange trading. Two novel Fish-eye-based visualization methods are used for visualization of high-density foreign currency exchange transaction in Section 6 and 7. Based on the performance evaluation of all above strategies in Section 8, we conclude and introduce our future work in Section 9.

2   Interactive Zooming

Zooming is a well-known technique, which is widely used in a number of applications. In displaying large and high-density data, zooming is useful for either highlighting specific region or capturing overall view in variable display resolutions. Zoom Out can be used to show the global trend or more transactions in large granularity, whereas Zoom In is used to show details of local samples or fewer transactions in small granularity in the same window.
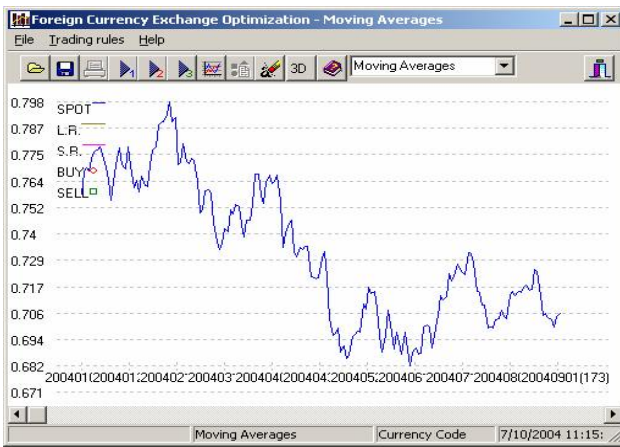

Figure 2 Zoomed details (x-coordinate is from 10 Jul. to 20 Jul. 1999).

Figure 2 is an example of Interactive Zooming technology used in visualization of foreign currency exchange data stream. The foreign currency exchange transactions from 10 Jul. to 20 Jul. 1999 are zoomed in more detailed way in Figure 2. Compared with what has been shown in Figure 1, more details are displayed here for the specific five days but losing information of global movement in the same window. In order to show both global trend of all targeted transactions and specific details in a window, we introduce some other approaches in the next sections.

3   Simple Sampling Visualization (SSV)

Given a foreign currency exchange transaction stream d_0, d_1, …, the length of stream is $|D|$, we divide the stream into $n = [\dfrac{|D|}{2^k}]$ ($k = 0, 1, 2, \dots, n$, $[\cdot]$ is upper round function) equal partitions (except the last one). In each partition, there is only one data record, which is extracted from the 2^k data according to some sampling strategies, displayed in the window. This is so called Simple Sampling of visualization.

Obviously, if $k=0$, then the result of the visual looks exactly the same as the original data stream in Figure 1.

Figure 3 shows the graph after sampling of data in Figure 1 by setting $k=7$. Compared with Figure 1, little difference can be seen there for large records inside, while the number of data points has been reduced to less than 1% of the original set.
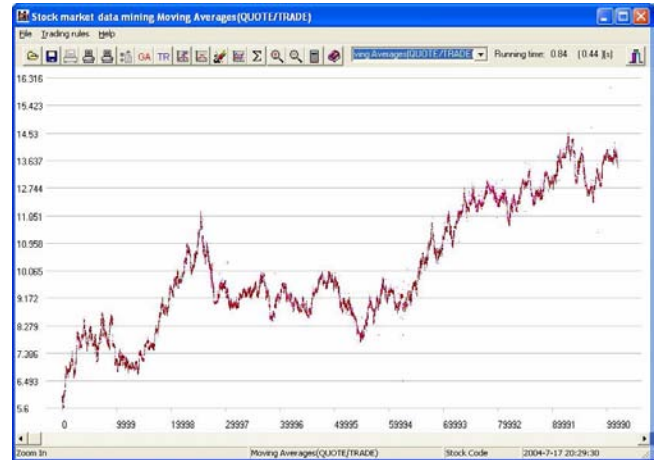

Figure 3 SSV ($k=7$)

However, some important details on the graph have been lost due to the largely discarded records in the stream. Moreover, it is hard to define and judge which record is more suitable for representing the other ($2^k - 1$) in terms of keeping more similarity to the original set. As an alternative, we will introduce the Value-Averaged Sampling in the next section.

4   Value Averaged Sampling (VAS)

In the final graph of Simple Sampling, for each data point, there is no consideration of contributions from other 2^k-1. In order to embody potential contribution from all 2^k data records, the averaged value of the total 2^k points is used for presentation. The length of data set and window size are the same as that of SSV.

The average of all data set with n records is calculated as:

$$\frac{\sum\limits_{i=2^{k-1}}^{2^k} d_i}{2^k}$$

Again, if $k=0$, the result is equal to what can be seen in Figure1. The result of VAS is shown in Figure 4, where $k=7$.

5 Candle-Bar Sampling (CBS)

Obviously, both SSV and VAS are generic methods which enclose little contribution from attributes in the problem domain. On the other hand, in foreign currency exchange market, the prices of open, close, high and low on a day are viewed as embodiment of important information. As a result, candle-bar, which consists of the above four prices, has been widely used in charting of foreign currency exchange transactions.
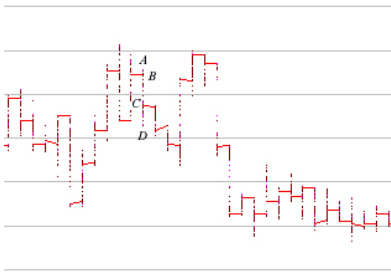

Figure 5 A-the highest, B-the first, C- the last, D- the lowest

To this end, we can combine the SSV or VAS with the candle-bars. What is different here from the usual candle bars seen in foreign currency exchange trading system, value candidates of open, close, high and low are represented by the first, the last, the highest and the lowest extracted from a data sample set in a targeted time period (as shown in Figure 5). The data sample set can be extracted from the original set in terms of certain strategies like SSV or VSM. The result of CBS is shown in Figure 6.

Up to now, for all the above three methods, SSV, VAS, CBS, there are information losing of both global and detailed. In order to keep both local details and global trend, we introduce the other two methods based on Fish-Eye technology in Section 6 and 7, respectively.

Figure 6 CBS (*n*=7)

6 Fish-eye view with Fixed Distortion (FFD)

Fish-Eye technology is a new technology of information visualization emergent with both development of data mining and web technology. In fish-eye technology, the graph appears in the graph window, the window is depicted by a distorted coordinate system, it consequently distorts the image of the graph. In the fish eye, the main point of interest is the focus, the focal area is magnified and shown in details. The parts of the graph that are further away from the focus appear slightly squashed, meaning the further nodes are positioned away from the focus, the smaller they appear in the graph window (shown as in Figure 7). (Lamping, Rao, Pirolli 1995, Szymon, Marc 2000)
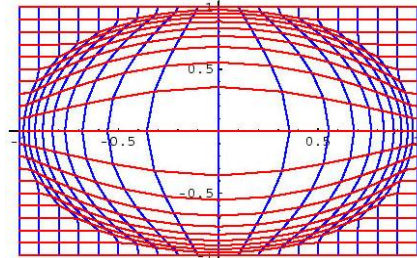

Figure 7 Cartesian fish-eye view (distortion scale is 4)

The advantage of data visualization based on fish-eye technology is on that specifically local details can be enlarged in a fish eye window, while the global trend can be kept in the limited window too. This is very helpful in showing a large amount of foreign currency exchange trading stream in a limited picture.

The basic idea of fish-eye-based visualization of data is as follows. Only a part captured from a graph is enlarged in details in the fish eye view, while all other parts outside the window are still shown normally, the purpose is we can get the local detail and global trend at the same time.

When we want to check details of some specific section on a graph, we just move the fish eye focus to that specific position (technically, moving the mouse and triggering a fish-eye view automatically).

We divide the graph into three parts: a section before fish-eye view, the fish-eye view, and a section after fish-eye view. Correspondingly, the data set behind is also distributed into three sub-sets which are related to the above three sections, respectively.
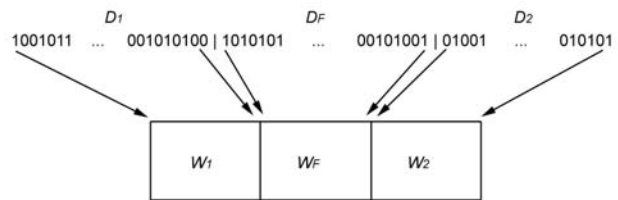

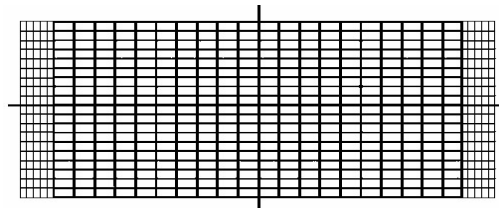**Figure 8** Both data set and window are divided into three partitions

Figure 9 Cartesian fish-eye view (one dimension).

D - the number of the whole transactions in the foreign currency exchange stream;

W - the width of the whole display window;

W_1 - the width of the section on the left of fish-eye view;

W_F - the width of fish-eye view, which is defined by users interactively;

W_2 - the width of section on the right of fish-eye view;

D_1 - the number of foreign currency exchange transactions in the section before the fish-eye view;

D_F - the number of foreign currency exchange transactions in fish-eye view, which is defined by users interactively;

D_2 - the number of foreign currency exchange transactions in the section after the fish-eye view.

So, when we visualize a data set, we'll divide the window W into three sections W_1, W_F and W_2, which shows data sub-set of D_1, D_F, D_2, respectively. The widths and positions of the three small windows will be distributed accordingly on the whole web interface window. Here, W_F and D_F are constantly predefined by users. After setting the mouse event triggering the capture of the fish-eye window in program, users can watch details of any points on the curve interactively by moving the mouse.

The width of window W_1 can be set by formula (1) as

$$W_1 = \frac{W - W_F}{D - D_F} \times D_1. \qquad (1)$$

W_2 can be calculated by formula (2)

$$W_2 = \frac{W - W_F}{D - D_F} \times D_2. \qquad (2)$$

The initial value of W_2 equals to $W_1 + W_F$. Correspondingly, the value of every data point in all three windows can be calculated and located in the interface window.

Figure 10 shows result of technical trading rule Channel Break Out. (Sullivan 1999)

Figure 10 FFD for Channel Break Out rules.

The data both inside and outside the fish-eye view is distributed into the window area proportionally in terms of time scale. This method is relatively simple, however it can show both details and global trends of a high-density

foreign currency exchange stream at the same time in a limited area.

It is sometime inconvenient for users to watch compare data near the window boundaries in and out of the fish-eye view. We'll introduce another strategy, Fish-eye View with Gradual Distortion in the next section.

7   Fish-eye with Gradual Distortion (FGD)

The fish-eye view with gradual distortion supports smooth transition in terms of multiple gradients from the focus of the graph to further away of the view boundary. Figure 11 shows the effect of FGD in the horizontal coordinate in the Cartesian system. (Basu, Licardie 1993, Hillol, Byung-Hoon, Sweta, et al 2001]
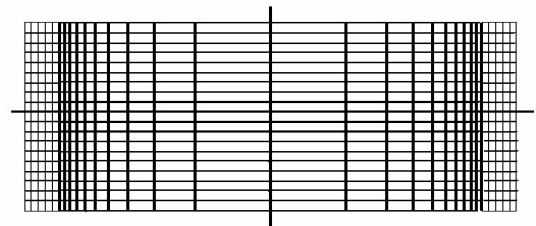

Figure 11 Fish-eye distortion on one dimension (distortion factor is 4)

From the focus of the fish-eye view to the boundary far away, the width of grid is getting smaller and smaller gradually. However, the number of data points shown in every grid is exactly the same. Graphically, it keeps changing smoothly from focus to the boundaries. For each grid, the strategy of point distribution can be defined flexibly, for instance, the FFD.

The application of fish-eye view with gradual distortion in foreign currency exchange stream visualization is shown in Figure 12 and Figure 13, respectively. In both of the Figures, there are 80 records which are distributed into each grid. As a result, the graph of the fish-eye view changes smoothly and continuously when we move the mouse interactively. (Keim 2002, Ivan, Guy, Scott 2000)

Figure 12 FGD for foreign currency exchange transactions.

As seen in the figures, FGD shows both regional details and global trend in different granularities at the same time. Furthermore, fish-eye view shows targeted focal

area in details with movement of the mouse on the graph smoothly.

Figure 13 FGD for Channel Break Out.

8   Performance Evaluation

The Interactive Zooming works very well when it is only used for showing specific details or browsing the global trends of high-density foreign currency exchange stream. However, it cannot be used to show both local details and global trends at the same time in one window. The Sampling including SSV, VAS and CBS can just be utilized for displaying the global trends rather than details in the same picture. Moreover, they lose information of "real" foreign currency exchange stream, and may bring about wrong conclusions in trading support even though we can add attributes like open/close/high/low values which are significant in foreign currency exchange market.

Fortunately, the fish-eye-based visualization can overcome shortages of both Zooming and Sampling. It can show both local details and global trends of high-density foreign currency exchange stream at the same moment in a limited window without losing information. This is very suitable for dealing with high-density foreign currency exchange stream.

With respect to complexity of coding, there is no big difference between Zooming and Sampling for web-based visualization if the sampling algorithm is not that complicated. However, it may be not that easy for online interactive fish-eye view. For some simple algorithms, the coding may looks not different from Zooming, but positioning algorithms of graph and focus may be complicated for other designs.

On the other hand, fish-eye view can present much user-friendly human computer interaction for flexible positioning and enlargement of targeted sections in details. In our online agent-based foreign currency exchange trading support system----F-TRADE----for trading back-testing, foreign currency exchange data mining, and foreign currency exchange trading support with online connectivity to real data of Australian Foreign currency exchange, we are integrating the fish-eye technology into it for visual outputs of foreign currency exchange trading signals, technical analysis, and data mining.

9   Conclusions and Future Work

In foreign currency exchange data analysis, both in data mining and technical analysis, the transaction stream is usually very large and of heavy density. The visualization of both local details of some specific transactions and global trends in the whole watch time period is very important for foreign currency exchange traders like brokers and retailers. We compared six types of methods for visualizing the foreign currency exchange transaction stream (LINLI).

By comparison, even though the complexity of coding and computation of fish-eye views may be flexibly high for some unique effects and breakthrough in visualization, web-based fish-eye views do present unique flexibility and user friendliness for visualization of very large and heavy density stream like foreign currency exchange transactions in a limited frame.

Besides studies in reducing complexity of computation and providing high performance fish-eye algorithms, a more practical strategy is to integrate fish-eye with other technologies like Sampling, achievements of query and processing of data stream, which will reduce complexity of computation in visualization of data stream, and provide visual functionality for watching high speed, real time data stream continuously. Therefore, a lot of research will be done in visualization of foreign currency exchange stream processing, foreign currency exchange data mining, and foreign currency exchange trading and support system by integration of fish-eye technology.

10   Acknowledgments

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