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Spacewarp

An immersive system to support pattern detection in financial data

Abstract

Every day when stock exchanges open, a huge amount of data arises from all over the world. Decision makers try to understand the future trends of the markets, but it is difficult to interpret the ongoing processes.

Our concept focuses on supporting the user in detecting significant patterns. For data representation we used the DAX and DOW JONES values of the last 5 years. Due to the periodic nature of financial data we decided to take a cyclic representation. We chose a geometrical structure which meets this criteria: the spiral.

The user is able to bend the spiral with a spatial interaction in order to find recognizable patterns. A common problem in information visualization is the focus-context-dilemma. The usage of an immersive environment improves the sense of spatial relationships. We suppose that although the user is focusing on finding recognizable patterns, the context remains perceivable.

1. Introduction

Nowadays the visualization of complex financial data is a common requirement at the stock exchanges. Normally the data are visualized in different two-dimensional graphs. To support pattern detection and to find analogies in the data, we are able to show many datasets aligned back-to-back in a spatial environment. For example investors try to recognize near future trends in the data to reveal the evolution of their single fund cells. Therefore they look for a relation between the fund and other important values like oil or gold. Many of these goods have seasonal fluctuations which may be compared with regard to their influence on the chosen funds.

We present a system which tries to combine a cyclic representation, intuitive interactions and an interface that displays additional information as a feedback about user interaction in an immersive environment. The main idea is to keep attention on the context while focusing on a detail. Therefore the initial user view is in the center of the representation that gives a 360 degrees overview.

2. State of the Art

According to a common classification of data, our graph represents a arbitrary number of numerical data [1] which are time-dependent and arises regularly on the market. Playfair [2] was the first who analyzed the efficiency of line graphs and bar charts. His work was described as the first major work which contained statistic graphs. Those were also used for the analysis of economic data.

The most common visualization techniques for time series data mentioned in «Visualizing Time-Series on Spirals» [3] are sequence charts, point charts, bar charts, line graphs and cycle graphs. Cycle graphs are used to visualize data with periodic background and with a known cycle length. Multiple data with the same format can be shown within one graph. Our Spacewarp graph combines some

Figure 1. User inside the CAVE

of the elements presented by M. Weber [3] and extends them, into a three-dimensional representation.

John Stasko and Eugene Zhang [4] describe three focus designs, «angular detail method, detail outside method and detail inside method». The idea which guided them to this design was to keep the overview of the whole hierarchy of a file system while providing the possibility of small peripheral files and directories. To be able to implement this concept they developed a two-dimensional circular spacefilling methodology.

Additionally for navigation in threedimensional information spaces C. Rosso et al. postulated that it is important for the user to have a spatial knowledge of the environment and a clear understanding of his location.

3. Cyclic representation

To find patterns in time series you can benefit from cyclic representation in different ways:

Cyclic representation promises to

- save representation space because of its compactness
- support the detection of periodic relationships
- support fast comparison of values appearing in the field of view
- support also different types of data, nominal, ordinal and categorical [1]
- support also trivariate and hypervariate data [1] (weeks, days, values, quote types)
- be visualized with a centered point of view to give the user a 360 degrees field of view (especially by using a surrounding projection system like a CAVE™ [9]).

Financial data can be represented by an Archimedean spiral, which is a continuous monotonic function in a xy-plane. The values of the chosen quotes are mapped on the spiral in direction of the xy-plane's normal in order to recognize cyclic pattern in

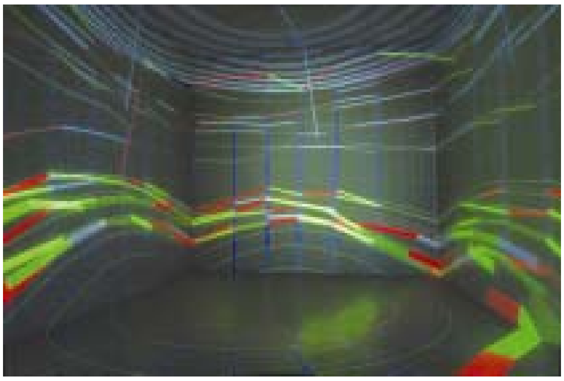

Figure 2. Centered point of view

these data values of the financial market.

For the Spacewarp application mathematical spiral formulas were derived to be viewed with the Lightning VR system [10]. At a very early stage the idea was to take an exponential spiral to balance the reduction of three-dimensional depth. But with a very huge dataset the Archimedean spiral gets more comfortable.

Finding cyclic pattern in the relation of different datasets is a common problem. The comparison between the different lengths of periods is also difficult. Therefore the system makes many different views available to ensure that the user can assemble the information for his individual needs. In this graph spatial interaction is used to search for recognizable pattern in complex datasets. The user handles with the bending of the spiral using an intuitive gesture and browses dynamically through the manipulated cycles. Although the spiral is bend its total length is preserved to provide the comparison of the quotes. Every new state of the spiral's bending generates a new dataset relationship and a new perspective to find patterns in. This ability should support our goal in finding patterns in surrounding datasets and between the discrete cycles.

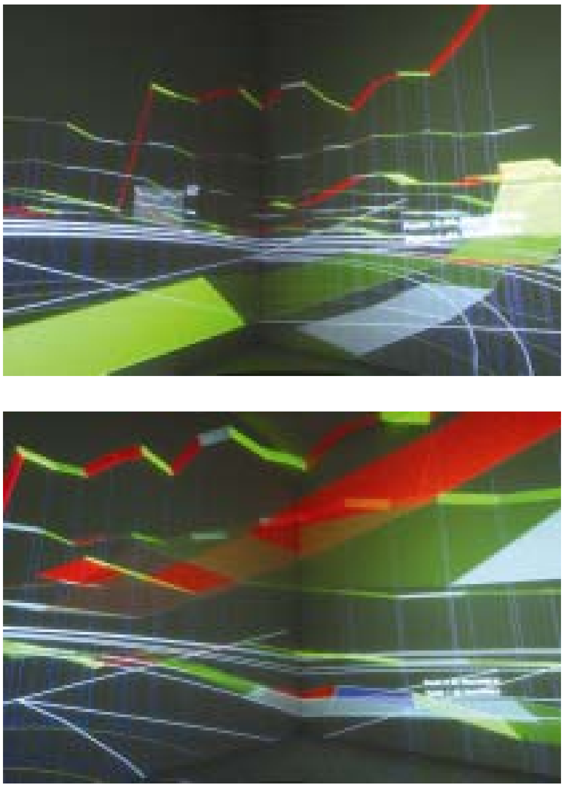

Figure 3. Selected segment

There are two modi of the spiral which generate different views. First, if nothing is selected, the points defining the spiral curve represent the absolute values of the chosen quotes. Second, if the user selects a segment of the spiral, the values of different quotes will be averaged for a better comparison of their gradient in a neighbourhood of that point. While focusing on the selected values one can see directly by looking at the spiral whether there is a boom or a regression. This information may relate directly to other quotes and time slots which can be seen on the convolutions of the spiral behind.

4. Implementation

In our demonstrator basic tools for quick user exploration of the datasets are implemented.

We have chosen deliberately an explorative approach without autonomic pattern detection methods to enable the user in finding an individual undistorted perspective on the dataset. The computer does not interfere autonomous, therefore the user has the possibility to choose values of his own interest for examination.

4.1. Color

To support our goal in finding pattern in the dataset, it is useful to color the gradients. The geometric representation of the values is supplemented by a RGB color scale method. The most extreme gradient of the dataset is defined and this one is mapped to maximum intensity of color. Accordingly all other gradients in the quote have a lower intensity of color. All booms have a green color scale and all regressions a red, therefore similarities can be detected easily without knowing the exact value of the quote.

The only polygons without these color values are the values with no gradient which are viewed in a darker grey. The selected segment is represented by a blue color.

This method supports very well the analysis of economic cycle booms or regressions by using a green-grey-red color palette.

Figure 4. Color coding

4.2. Interface

The user is exclusively manipulating the spiral. He does not interact directly with the virtual screen, thus he must not focus on it in order to trigger additional information.

It is best to offer all possible options according to a direct see-and-point-principle. [6] By doing this, the interface must make sure that the user does not need to make any excessive effort to identify an option, nor to understand it, nor to activate it.

We are able to support this criterion in our program, because it is a very specialized application to support pattern detection in financial data.

4.2.1. Selection

Selection of spiral segments is used to change the spiral's mode described in chapter 3. Each time a spiral segment is selected this input is used to trigger additional information displayed on the virtual screen.

The user has two possibilities to select values of interest.

The first interaction technique is the selection of spiral segments with a ray. This selection ray can be described as a virtual laser pointer which has its origin in the three-dimensional input device. Segments are selected by intersecting the ray and pressing a button. The ray interaction is a position controlled manipulation technique [7], that is fast and comfortable within the user´s interaction range extended by the ray.

The second interaction is an additional manipulation technique to select segments that are far away with a small micro joystick on the three-dimensional input device. If a segment is selected it is possible to move left and right on the spiral or to jump forward and backward across the loops of the spiral. Manipulating the scene with the joystick is a force control manipulation technique [7], that makes sense to use beyond the users interaction range. While searching the dataset for pattern it is useful to have both possibilities to manipulate the scene in order to have a more detailed exploration of the data.

4.2.2. Navigation

The Navigation enables that the user can get a fast and informative view on the scene. Therefore we use two nonisomorphic navigations.

Bowman describes isomorphic [7] manipulation techniques as a strict, geometrical, one-to-one correspondence between physical and virtual world motions. Although this interaction seems to be preferable in virtual environments we have chosen to use nonisomorphic manipulation since the user should select values out of his physical range.

Inside the CAVE™ we use three navigations, two user navigations and one datanavigation. The user navigations move the position of the user in the scene and the data navigation animates the users view on the datasets.

An advantage of a virtual environment is the direct interaction in space. The first user navigation utilizes this fact. It is a physical navigation of the user inside the CAVE™

(2,9x2,9x2,7 meter) that is fully isomorphic [7] tracked. The second user navigation enables the user to change his position within the virtual scene by pointing in the desired direction.

Our data navigation uses a spatial gesture triggered by a button to transform the rotation of the hand to the curvature of the spiral. This is a very simple and effective technique, since the gesture is directly widening or tightening the spiral just by turning the hand in the proper direction.

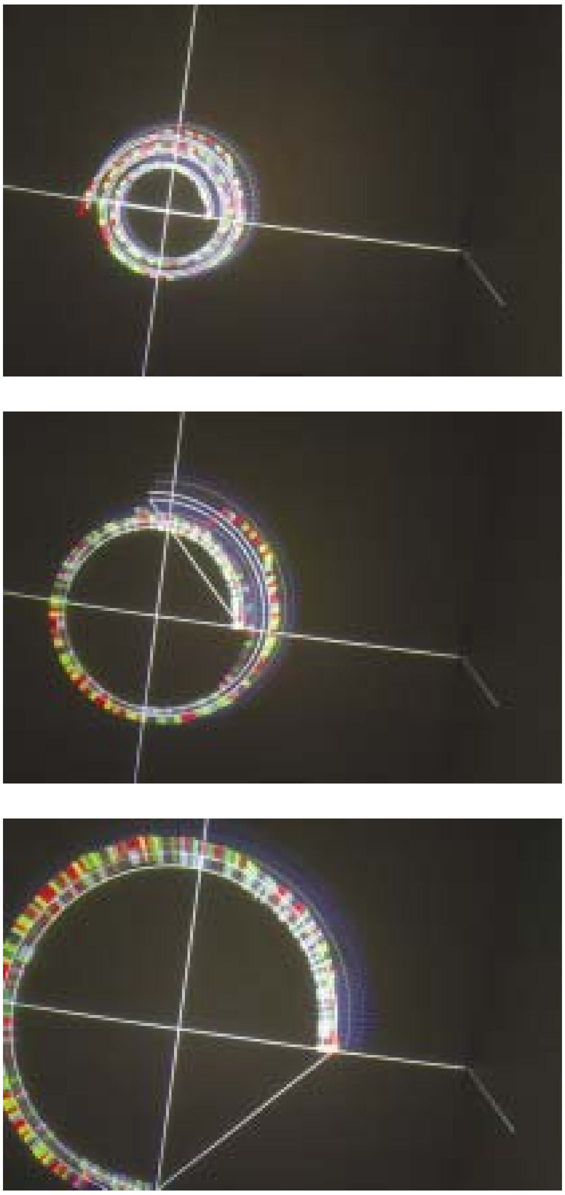

Figure 5. Spiral's bending stages

The combination of these two manipulation techniques supports an intuitive and flexible preoccupation with the data.

For seamless immersion real-time computation of the bending of the spiral is necessary. Immediate switching to the new view without transitional animation of the spiral would disturb the user´s spatial awareness of the context and his clear understanding of his location. Therefore the spiral's bending is animated by three different velocities which depend on the change of the angle in which the hand rotates after the button was pressed.

This smooth animation of spirals keeps the relationship to the earlier arrangement of the spiral segments tracked.

4.2.3. Virtual screen

The user has two virtual screens to look for additional information assigned to the selected segments.

The first virtual screen represents the value of the selected quote point in time, by displaying the value as a text beside the selection ray. This display technique does not mask the surrounding representation, since it is bound to the users hand motion.

The second interface - a billboard [8] - is a plane orientated on the view which displays a more detailed resolution of values than the spiral. The spiral visualizes weekly values, whereas the billboard interface shows everyday values.

To align the billboard the user can grab the interface with the ray to move it into the favoured position in the virtual environment. This billboard interface also follows the user only if a maximum distance is reached. It is more desirable that the billboard must not move all the time, but if it gets out of range it will follow the user to guarantee that he does not loose the additional information in his area.

Figure 6. Billboard interface and spiral representation

5. Conclusion and future work

We have designed and implemented a first demonstrator to support pattern detection in financial data. Our focus is to support the user with tools which enable him to find pattern of his individual interest.

We have chosen a spiral representation that generates an environment where analogies can only be seen within the context. The user has the option to look for additional information about the values represented by the spiral on the virtual screens, but this information does not hide the context.

The current implementation has limitations with bending of the spiral in real-time which disturbs user perception in the immersive environment. Therefore the next step is to benchmark the used procedures for a faster access to the data since the warping of the linear timeline into the adjustable spiral provides necessary views.

Although not evaluated we have informal evidence that Spacewarp supports better pattern finding than linear representations. In addition it seems that the immersive environment keeps a better track on the context which promises a reduction of the focus-context-dilemma. Even if immersive environments have a low penetration in productive environments we think that especially for information visualization its usefulness can be seen today.

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