sMAX

A MULTIMODAL TOOLKIT FOR STOCK MARKET DATA SONIFICATION

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ABSTRACT

In this work, we present sMax a multimodal toolkit for stock market data sonification.

Unlike most research focusing their effort primarily on the sonification of single stock information, sMax provides an auditory display for the user to monitor parallel distributed data. sMax uses a set of Java and Max modules to map real time stock market information into recognizable musical patterns. One of the main design goals of the toolkit is to allow low-latency controls over real-time data sonification. Because of its object-oriented architecture, sMax can be easily extended by the user when additional functionality is required.

The project outcomes range from the creation of art installations to auditory display for mobile computing devices.

We present the theoretical background, and the structure of the program.

1. INTRODUCTION

Sonification of real financial data is an interesting field of enquiry for composers, researchers and market traders.

Composers may be interested in combining sonification outcomes in their music for aesthetics purposes [1, 2, 3]. An interdisciplinary research effort is particularly inspiriting when graphical representation of multidimensional data falls short of affording us an immediate insight as in the case of stock market data. There are at least two reasons to explore the musical potentiality of financial information sonification.

First, as the rate of change in stock prices is often sharp and unexpected, unforeseeable sonic result might occur in the sonification of stocks data. Secondly, the inner and subtle correlation of stock price variations may be considered similar to the correlation of patterns within a musical composition.

On the other hand, stock market environments, in which large numbers of changing variables and/or temporally complex information must be monitored simultaneously, are well suited for perceptual research in sonification.

It has been shown that the auditory system is very useful for task monitoring and analysis of multidimensional data. Yet, auditory designers must gain an understanding of how many different auditory information streams can be monitored without loss, as well as how memory load, attention mechanisms, and other cognitive processes affect information transfer. A major question is how to impose the *primitive* auditory and *schema-based* auditory organisation suggested by Bregman [4]. In a *primitive* organisation a sequence segregates into two primitive sub-sequences when conditions are in favour of the streaming phenomenon (e.g. fast rates, large frequency separation, different timbres, spatial separation etc.). In a *schema-based* organisation the listener can switch between hearing a sequence as one or two streams by changing attentional focus. In this case the streaming phenomenon depends on conscious effort and learning. In addition, stock market data sonification may shed light on other well-known issues of data sonification such as orthogonality [5] (i.e. changes in one variable that may influence the perception of changes in another variable), reaction times in multimodal presentation [6], appropriate mapping between data and sound features [7], and average user sensibility for subtle musical changes [8].

Finally, market traders may find desirable to use sound as the "display" medium for the purposes of facilitating the interpretation of financial data. It is very difficult to model the complex dynamics and interactions that drive the stock market. Traders attempt to determine relationships between the data attributes that can lead to profitable trading of financial instruments. In order to address the issue, visual displays on computers are commonly used in the form of bar charts and graphs. However, the graphical representation of complex data often falls short of affording us the clear and immediate insights that graphs offer for simpler data. Moreover, monitoring data through visual display is tiring and stressful because it requires staring at a fixed place for long periods of time. In this context, our ability to track multiple acoustic variables could be used to render interdependent variables onto sonic structures. Thus, providing listeners to gain important insight into the meaning of the represented information, while reducing visual data overload.

2. BACKGROUND

In the last ten years, stock market data have been a subject for sonification researchers.

Frysinger used directly played-back stock market price data as a sound waveform [9]. The sounds were difficult to interpret. This was attributed to the fact that the time series of stock market data did not follow physical-acoustic laws that characterise the typical sounds from everyday experience. Stock market price data for a single share were mapped to pitch in an experiment by Brewster et al [10] to test the idea that sounds can be used instead of limited screen space in a mobile PDA device. Results showed no difference in performance using either the sonification or a line graph to monitor the price over time, but subjects reported a significant decrease in workload with the sonification that allowed them to monitor the price while using the visual display to buy and sell shares.

Both price and volume for a single stock were sonified by Nuehoff et al. [5]. Price was mapped to the frequency of a tone and volume to the amplitude. The results show perceptual interactions and asymmetries could potentially distort the interpretation of the display.

Price and volume for two stocks were sonified simultaneously by Ben-Tal et al. using two different vowels. [11]. The sonification of historical data at a "playback" speed faster than the occurrence of the original information has been used to discover larger scale trends or patterns in financial data.

Nesbitt and Barrass designed a multimodal display to help traders make better decisions from depth of market stock data. The results suggest that subjects can predict significantly better than chance the direction of the next trade [6].

Despite the demonstration of the viability of stock market data sonification, the field remains almost exclusively in the laboratory. Significantly, when dealing with real time data monitoring in a fast-paced stock trading room a number of perceptual issues arise. If few stocks are considered, data properties are revealed by distinct auditory events that can be heard without overly demanding training. Yet, sonification of several stocks in a highly active market easily produces a continuous hubbub texture in which multiple streams are difficult to detect. In addition to the disadvantage mentioned above, the repetitive and artificial nature of audio output can become irritating and distracting, causing fatigue.

In order to address the issue, we present sMax, a multimodal toolkit for stock market data sonification. Unlike most research which focus effort primarily on the sonification of single stock information, sMax provides an auditory display for the user to monitor parallel distributed data sets.

3. SMAX DESIGN

sMax has five components:

- the data manager module
- the mapping module
- the user interface
- the visual display
- the MIDI manager module.

The data manager module collects the data accessible through on-line resources to learn essential information about a list of stock arranged by the user. A console provides feedback about result and latency of ongoing processes. In order to minimize download time, information for each stock is organized into static and dynamic fields. Static data include ticker name, average daily volume, market capitalization, and previous close price. Dynamic data include time, price and volume of trade of each stock. At runtime, the data manager module feeds static and dynamic data to the mapping module. Refresh rate of dynamic data is about 200-600 milliseconds depending on network traffic.

The visual display consists of three windows. The main window (Fig. 1) conveys to the user both musical and financial characteristics of data. Information is organized in rows and columns. Each row displays the following:

- stock symbol
- price of the last trade,
- price and percent deviation from closing price
- deviation from the previous detected price
- average daily volume
- average daily volume deviation
- mean velocity of the last pattern of MIDI events
- reference MIDI note number
- last detected MIDI note number
- musical instrument associated with the data

Information is "colorized" by negative/positive price variation, providing an overall view of the "mood" of the market. Editable *solo* and *mute* buttons allow filtering and zooming along the data set. Two smaller windows keep track of the major fluctuations in price and sudden increase in volume. This information is mapped to five ordered levels of importance. Displayed data include the symbol used to identify the stock, the level of importance and the name of the musical instrument associated to the data.

The user interface offers real-time controls of mapping parameters, scaling functions and thresholds. The relationship of the various parameters to each other can be saved and recalled. By making adjustments to the GUI sliders and buttons, the user may adjust the overall "sensibility" of the system.

The mapping module keeps track of how the data are to be mapped to MIDI. Rather than mapping data directly to MIDI messages, the module uses the data manger output to generate dynamic musical patterns by means of multiple mapping algorithms. None of these patterns are pre-calculated, they achieve their behaviour exclusively through data variations. Mapping algorithm design has been focused on the fast presentation of concurrent musical patterns and the exploitation of their emergent gestalts.

Finally, the MIDI module is responsible for initialising the audio device and causing it to create a particular sound.

The module provides a sound legend that can be sonified to preview the effects the sound mapping would have on data before an entire data set is sonified.
The data manager module is written in Java for portability, easy maintenance and adaptability to different on-line resources. The rest of the components have been created using Max/msp programming environment because it is (i) flexible, (ii) available on many platforms, (iii) well supported through the specification of many free, easily available and editable examples (patches). The MIDI

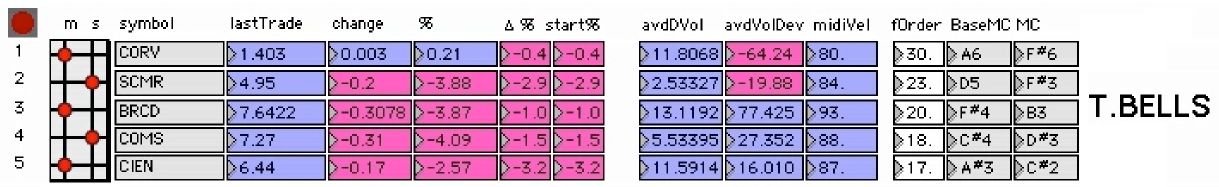

Figure 1. *A particular of sMax visual display.*

protocol is used in order to afford easy connections to professional hardware/software packages as well as consumer multimedia products.
The goal of sMax architecture is twofold. On one hand, it makes it possible to implement a lightweight sonification tool for users that are not interested in the design of the sound itself. On the other side, the toolkit provides a platform for quick prototyping and combination of different audio or MIDI processing modules, when additional functionality is required.

4. CONCLUSIONS

Art-technology collaborations are often crucial to the successful design of audio displays where expertise in sonic treatment is necessary [13, 14]. Within this framework, we presented sMax" a multimodal toolkit for stock market data sonification. A primary goal in the design of sMax is to provide a toolkit for use in monitoring parallel-distributed financial data sets. Extended real-time control over almost all auditory display parameters provides the user with an effective mean to tune the information-conveying capacity of the sonifications. Preliminary results show that it is not unreasonable to hope that the system can be adapted and extended for use in art installations [14] as well as in auditory display for any computing devices. In order to finalize the implementation full user studies would need to be undertaken. Finally, although the system has been described with respect to the representation of data related to trading stocks, it should be noted that the system is also applicable to any large multidimensional data set.

5. REFERENCES

[1] M.Ballora.. "Heart Rhythms: Healthy", performed at *Conference of the Society for ElectroAcoustic Music in the United States* (SEAMUS), USA, 2002. Information available at: http://www.music.psu.edu/Faculty%20Pages/Ballora/sonification/hrhythms.html

[2] N.Barrett, "Displaced: Replaced I I", performed at. *International. Computer Music Conference*, Göteborg, Sweden, 2002. Information available at: http://www.notam02.no/~natashab/dr2/displacedII.htm

[3] O. Ben Tal. "Tangents for flute piano and tape". performed at CCRMA, Stanford, California, USA, 2003. Information available at: http://ccrma-www.stanford.edu/groups/soni/tangent.html

[4] S. Bregman, *Auditory Scene Analysis: The Perceptual Organization of Sound*. MIT Press, Cambridge, Massachusetts, 1990.

[5] J. G. Neuhoff, G. Kramer, J. Wayand. "Sonification and the Interaction of Perceptual Dimensions: Can the Data Get Lost in the Map?" in *Proceedings of the 2000 International Conference on Auditory Display* Atlanta, Georgia, USA, April 2000.

[6] K. V. Nesbitt, S. Barrass. "Evaluation of a Multimodal Sonification and Visualisation of Depth of Market Stock Data". *International Conference on Auditory Display - ICAD 2002*, Kyoto, Japan, July 2002.

[7] B. N. Walker and G. Kramer "Mappings and Metaphors in Auditory Displays: An Experimental Assessment" *International Conference on Auditory Display - ICAD 1996*, Palo Alto, California, November 1996.

[8] P. Vickers and J. L. Alty. "Towards some Organising Principles for Musical Program Auralisations", in *Proceedings of the 1998 International Conference on Auditory Display*, Glasgow, England, November 1998

[9] S.P. Frysinger, "Applied Research in Auditory Data Representation" in *Extracting meaning from complex data: processing, display, interaction. Proceedings of the SPIE*, vol 1259, pp. 130-139, 1990.

[10] A. Brewster and R. Murray. "Presenting Dynamic Information on Mobile Computers", *Personal Technologies*, vol 4, no.2, pp 209-212, 2000.

[11] O. Ben-Tal, J. Berger, B. Cook, M. Daniels, G. Scavone and P. Cook, "SONART: The Sonification Application Research Toolbox", *Proceedings of the 2002 International Conference on Auditory Displa*y, Kyoto, Japan, July 2002.

[12] M. H. Hansen, B. Rubin. "Babble Online: Applying Statistics and Design to Sonify the Internet", in *Proceedings of the 2001 International Conference on Auditory Display,* Helsinki, Finland, 2001.

[13] Sturm, B. L. "Surf Music: Sonification of Ocean Buoy Spectral Data", in *Proceedings of the 2002 International Conference on Auditory Display*, Kyoto, Japan, July 2002.

F. Cifariello Ciardi "The Sound of NASDAQ" premiered at 40° Festival di Nuova Consonanza, Rome, Italy. Information available at: http://www.edisonstudio.it/ciardi/popup/soundofnasdaq/popup01.html