A System for the Musical Investigation and Expression of Levels of Self-Similarity in an Arbitrary Data Stream

David Rossiter  Wai-Yin Ng
rossiter@ie.cuhk.edu.hk  wyang@ie.cuhk.edu.hk
Department of Information Engineering
Chinese University of Hong Kong
Shatin, Hong Kong

Abstract

This paper presents a system developed for the analysis and subsequent musical expression of data performance at an arbitrary number of levels of self-similarity within an arbitrary (linear) data sequence. The system employs two software components; the Csound audio generation software and a program to manage the data processing and file handling. System structure and operation is described, with an example based upon analysis of the Dow Jones financial stock market index data.

1 Introduction

Over the past decade or two there has been a massive expansion of interest and research in the area of fractals (see, for example, Gleick, 1987). Fractal patterns have been seen in a vast variety of phenomena. Fractals exhibit self-similarity in which the mathematical properties of the data are similar regardless of the level at which the data is being examined. Today, research continues with investigations into self-similar properties of data ranging from stress patterns of earthquakes to different depths (Derosa, 1995) to World Wide Web traffic (Crovella & Bestavros, 1995).

Self-similar properties are similarly evident within pitch and music structure (i.e. Rosenboom, 1992) and have been directly embodied in musical compositions (i.e. see Econ, 1992).

Analysis of levels of self-similarity (currently processed via graphical representations) may therefore be suitable for analysts in the sound domain, in which properties of sound and music may be used to reflect levels of self-similarity in patterns of data. In this paper a system is presented that has been developed to enable this form of analytical expression, which is termed saxification.

The system can serve both scientists and artists who seek to express data in a musical form. The former may use the system as a tool for enhancing conventional data analysis techniques for investigating self-similarity in data streams, such as fourier analysis and chaotic modeling. The latter may use the system as a compositional tool to express hierarchical patterns of non-musical data in a musical form.

2 Implementation

The system is currently implemented under a Unix environment. It employs two programs. One is the public domain Csound audio generation software. The other, called Audiostream, is a program developed for the task of managing the file handling and data processing tasks involved. Both pieces of software are written in the C programming language. This enables maximum ease of portability between different systems. Pre-compiled binaries of the Csound software are also available for most computer platforms.

The Csound program currently requires two files for operation. One is the orchestr file in which the technical description of the sound-generating instrument(s) is provided, and the other is the score file, in which variables and directions concerning the timing and control of the instrument are given.

Prior to operation, the user edits a configuration file with the required sonification parameters. This file is then loaded during the start-up procedure of the Audiostream program. In the file, the user may select a number of pre-designed Csound
3 Performance issues

The system may be effectively used to musically express an incoming stream of data in real-time, or non-real-time. However, this is dependant on the timing of the incoming data and the workload on the underlying hardware. Through the use of the Csound system a range of instruments may be precisely designed with regard to an appropriate balance between real-time performance and processor capability. Instruments may be selected from those already available in the public domain.

A configuration of instruments may be selected according to the particular requirements of the user. For example, an analyst seeking to explore patterns of data at different levels may choose instruments of acoustically similar but distinct properties by employing a selection of different instruments from the same orchestral class. An example from the chordophone classification group of instruments is the combination of double bass, guitar, and violin for the expression of a three-part analysis.

4 An illustration

In this illustration, data has been taken from the world of finance. Analytical techniques in this field have expanded over recent years (Solomon, 1996) and a sonified analysis may serve it well. The data used is the end-of-day closing Dow Jones index data over approximately a 6-year period, during which the infamous 'wall street crash' occurred (October 19, 1987, when the Dow plunged more than 500 points to a value of 1738). In figure 2 the original index data is shown in addition to the output of three moving average data window analyses of the data at different levels of scale (and with different degrees of offset for the sake of clarity). Data offset values have been applied to each of the three analytical data streams. Parameters of the first analysis are selected to exhibit trends in data across a relatively small time-frame, 50 days. The second involves an analysis across a 100 day period, the third across a 400 day period. The vertical axis shown may be mapped uniquely to each instrument. Standard sonification parameters include fundamental frequency, amplitude and output duration. A greater level of expression may be achieved via the appropriate design of new Csound sonification instruments so that any aspect of acoustical information may be exploited. The contrast between the essentially upward trend derived from the longest window and the original data indicates the differing conclusions that may be drawn according to the level at which the data is examined.

By adjustment of the configuration parameters, the data may be presented in many alternative forms. For example, by adjusting the time offset and multiplier parameters self-similar levels may be consecutively expressed one after the other. This is illustrated in figure 3. Further treatment could include layering for simultaneous expression of a selection of similar or different instruments, or some form of combination.

5 Conclusions

The structure and operation of a system for the acoustical investigation of levels of self-similarity has been presented. As it stands the system may be usefully employed in this context, although it would benefit from a number of enhancements. The ability to concentrate on a small subset of the data and to interactively alter parameters in order to determine the most suitable configuration are primary considerations for future development.
References

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Figure 2 Three window output streams with original data

Figure 3 Three window output streams expressed as consecutive time sequences (with line of best fit)

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Figure 1 System structure and operation

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