STUDIO REPORT OF THE UNIVERSITY OF LEEDS DEPARTMENT OF MUSIC

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Abstract

Current studio facilities and research of the Electronic Studio at The University of Leeds are reported.

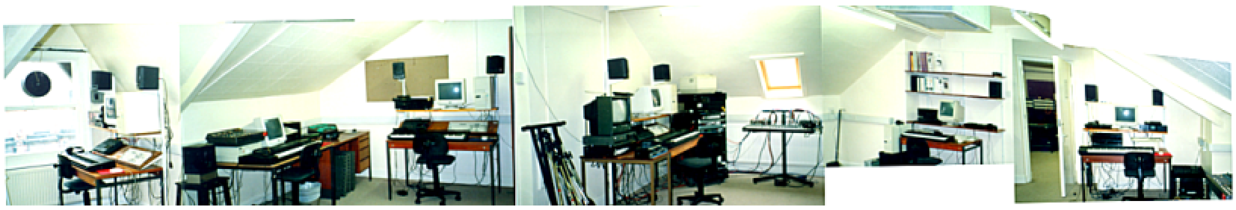
1. Introduction

Since its inception in 1987, the Electronic Studio of the Department of Music at the University of Leeds has expanded from its humble beginnings in one small room, into a comparatively substantial facility spanning most of the upper floor of the Department. It provides the infrastructure for undergraduate and postgraduate studies in music technology, research and composition. The Leeds Computer Music group, hosted by the studio, currently consists of members of the Music Department, the School of Computer Studies and the School of Electronic and Electrical Engineering and fosters a direct and close collaboration between composers, programmers, engineers and researchers.

2. Studio

The Electronic Studio facilities (see Figure 1) are mainly PC based, though a Silicon Graphics Unix workstation and Acorn RISC PC (running Sibelius 7) are also available. All PCs are networked and can share resources. Studio 1 is primarily used by advanced undergraduates and postgraduates and provides a substantial array of synthesisers, samplers, audio processing units, with eight- and two-track digital recording facilities and a MIDI automated mixer, as well as hard-disk recording and editing. An integrated professional-quality video recording set-up and synchronisation facility is also available. Studio 2 has six workstations (one with a CD production facility) and a further video set-up. A third studio has a networked computer cluster devoted to music processing, Csound and general use. All studios are equipped with industry-standard software, including Cubase, Finale and Csound.

(a) Main setup in Studio 1.



(b) A panoramic view of Studio 2.

Figure 1: Images of the studio.

3. Research Projects

In this section, brief summaries of current areas of computer-music research are presented, with some technical details of specific methodologies and references to recent publications.

3.1 Optical score recognition

Our interests in optical music score recognition was initiated in 1991 [Ng *et al.*, 1995, Ng, 1995, Ng and Boyle, 1996] and we are currently porting our UNIX based prototype, onto the PC platform. This prototype, designed for printed music, attacks complex notation by sub-dividing composite groups of features into low-level graphical primitives, such as note-heads, stems and beams, before recognition, and then reconstructs the final results using the primitives with the assistance of musical syntax and conventions (see Figure 2). This works well on printed scores and provides a useful intermediate stage where many neighbouring primitive classifications can be checked and confirmed with each other. However, the sub-segmentation process relies on the straight edges of the symbols and it is not robust when dealing with hand-written manuscripts because of their typically slanted line segments [Ng *et al.*, 1996a].

(a) *(b)*

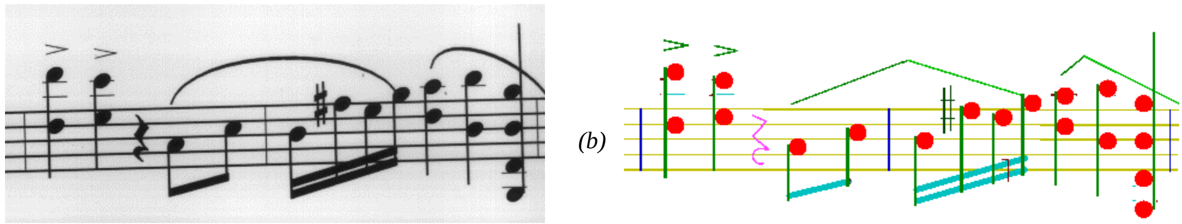


Figure 2: (a) An example input and (b) the reconstructed result.

As a result of competitive bidding, the University of Leeds has provided a grant of £90,000 to support the development of an OMR system for hand-written manuscripts by the authors. An institutional bid for funding the project has also been submitted by the University of Leeds to one of the UK's national educational research funding organisations, and the result of the process is currently awaited.

3.2 Tonal analysis

In order to substantiate assertions of vestigial tonal traces in non-tonal music, a measure is required, against which the degree of residual tonality may be judged. Such a measure has been developed by Kia Ng, David Cooper and Roger Boyle as a by-product of work on the OMR system described above [Cooper, 1998]. The forty-eight preludes and fugues of Bach's *The Well-Tempered Clavier*, Books I and II, in MIDI file format provided an initial data set for analysis. Two types of information are extracted from the MIDI files: the frequency of occurrence of each of the twelve pitch-classes, and the total duration associated with each pitch-class (the sum of all individual durations). Each pitch-class is ranked from 0 to 11 according to its total duration, the pitch-class with the longest total duration being given the lowest numerical ranking (see Figure 3). After analysis of the training data, an algorithm was designed which, in a mechanical way, is able to simulate the process of key-signature detection (and thus underlying tonality) with considerable accuracy [Ng *et al.*, 1996b].

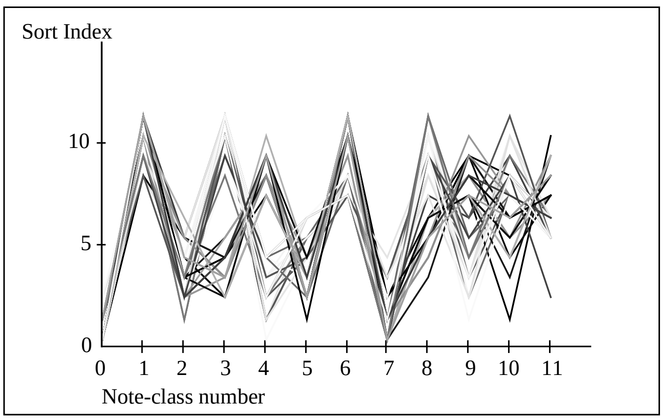


Figure 3: Semitone offset from tonic compared to ranking (sort index) by duration for the training data.

3.3 Music notation file format – Expressive MIDI

The ExpMIDI file format (Cooper et al., 1997), an extension of the standard MIDI file, was developed as an output format for the Leeds OMR system. Note names and lengths can be explicitly coded, and most 'expressive' details included (dynamics, hairpins, standard expression marks and so on). As the format makes use of an existing hook in the MIDI specification, ExpMIDI files should be playable on any MIDI-file conformant rendering engine, as playback systems should ignore any events they do not recognise.

3.4 Tuning by Ratios using Csound

In his monumental work, *On the Sensations of a Tone*, the eminent 19th century German scientist Hermann Helmholtz proposed a tuning system in which frequencies are tuned according to simple ratios. It is now possible, using digital audio synthesis software such as Csound, to explore this theory in detail. Through various musical illustrations supported by Csound orchestra and score files, postgraduate research student Robert Asmussen's paper demonstrates that simple ratios of frequencies (such as 2:3, 5:4) are at the very heart of traditional Western tonality (see Figure 4). Included in this paper is a set of computer programs in C that may be used to reprocess and expand existing Csound scores. For more details, see http://www.leeds.ac.uk/music/Studio/lcmg/sw/tuning/tuning.htm.

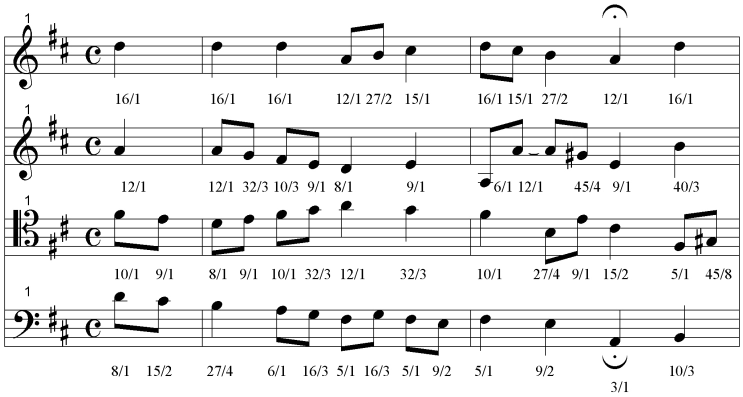


Figure 4: Bach Chorale harmonisation tuned by Helmholtz ratios.

4 Final-year Undergraduate Projects

As part of their final-year work for the BA in Music and Electronic Engineering, undergraduate students have been building a system on a Unix platform for the gestural capture and parameterisation of a data from live musician which can be used to control a synthesiser implementing a physical modelling algorithm. An input signal from a microphone is digitised and windowed and Fourier Transforms are calculated every 0.01 second (a phase-vocoder implementation is felt to provide the most efficient means of data analysis). A number of parameters, including the fundamental, several formant frequencies, their associated magnitudes and the peak to average magnitude are passed to a mapping section which converts them to appropriate variables for the synthesis engine.

The Departments of Music and Electronic Engineering are currently negotiating with the manufacturer of an innovative and high-profile hardware sequencing device to establish several research studentships for the further development of hardware and software. It is hoped that one or more of our new graduates may be involved in this exciting new venture.

4.1 Music and Fractals

The relationship between 1/f noise and music proposed by Voss in his Ph.D. thesis of 1975 and subsequent papers published in *Nature* and the *Journal of the Acoustical Society of America* still dominates discussions of the connections between fractal geometry and music. Voss's experimental work showed that the power spectrum of a signal which has been squared and passed through a 20Hz low-pass filter (which for Voss is a correlate of the instantaneous loudness of the music the signal represents) has a 1/f shape when plotted as a log-log graph. A similar graph was found for the power spectrum of the instantaneous frequency (using a zero-crossing measurement methodology), which Voss relates to musical pitch. It is now, perhaps, appropriate to reconsider what his results imply from the point of view of music. We have discovered, that the amplitude spectra of musical signals, when observed over different time scales, are similar (see Figure 5). In Fractal Geometry this property is called self-similarity. An on-line version of the paper is available at http://www.leeds.ac.uk/music/Studio/lcmg/es-rrs.html [Henze and Cooper, 1997].

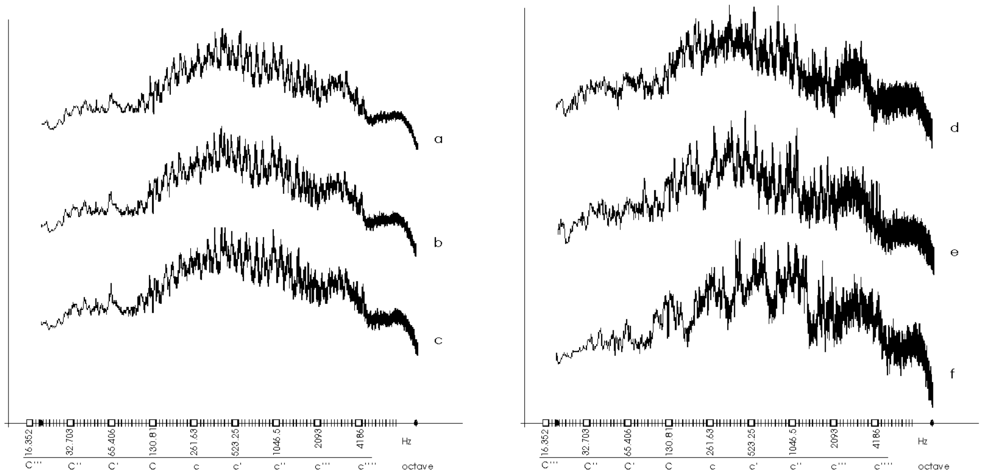


Figure 5: Palestrina: 'Osculetur me osculo oris sui' a) entire piece; b) half of the piece, centred; c) quarter of the piece, centred; d) five sec; e) five sec, extreme gap; f) two sec, highlight

5. Concerts and Demonstrations

An international festival of the British Association for the Advancement of Science held at the University of Leeds in Fall 1997 included performances of works for live instruments and electronics and software demonstrations, and was attended by some 300 journalists and 1500 visitors. Several other concerts of electronic music were held during the year.

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