Using Music as a Communication Medium

James L. Alty
Department of Computer Science Loughborough University
Loughborough
Leicestershire, UK, LE11 3TU
+1509 222 648
j.l.alty@lboro.ac.uk

Dimitrios Rigas
Department of Computer Science Loughborough University
Loughborough
Leicestershire, UK, LE11 3TU
+1509 222 648
d.rigas@lboro.ac.uk

Paul Vickers
School of Computing and Mathematical Sciences
Liverpool John Moores University
Liverpool, L3 3AF, UK
+151 231 2104
p.vickers@livjm.ac uk

ABSTRACT
Music is a rich communication medium, and there are some similarities between the job of a music composer and that of an HCI designer (although their objectives may be different). Whilst sound has been used in interfaces, its use has mainly been at a primitive level, often involving real-world sound. Since music offers a highly structured set of mechanisms for communicating, it is surprising that there have been so few attempts at exploring its possibilities. Our current activity involves investigations into the use of music in algorithmic audiolisation and program debugging.

Keywords
Music, Interface Design, Debugging, Multi-media, Audiolisation.

INTRODUCTION
Most output activity in HCI research has concentrated on the visual medium, and many investigations involving a large number of output media have been presented. The auditory medium, on the other hand, has been exploited only to a limited extent. Since Bly's original thesis [1] on the use of sound in interfaces, attempts have been made to design and build the aural equivalent of visual icons, or "earcons" [2][3], voice output and artificial or natural sounds are now used fairly routinely, and systems such as the SonicFinder [4], which uses natural sound to indicate the state of the natural environment, have been described The auditory channel has also been used to augment the visual channel in algorithm visualisation [5] and to assist in physical process audiolisation [6]. However, the potential for using music as an output medium (the most sophisticated of the auditory media) has hardly been examined at all apart from some use of music in data analysis [7]. For a full discussion of the possibilities offered by music in HCI see [8].

THE IMPORTANCE OF AUDIO IN INTERFACE DESIGN
The Audio channel is an important information channel, and has a long established tradition of conveying rich meanings. However, there is another important reason for encouraging more research in the area. The explosive growth in visual interfaces (such as GUIs) has put visually-challenged people at a considerable disadvantage. Most interfaces now carry an implicit assumption that the recipient has excellent visual capabilities. Such a situation is particularly upsetting because blind and partially-sighted users were, until recently, making great strides forward in using computers successfully, (for example, using screen readers). Unfortunately, screen readers cannot successfully describe GUIs. In an ideal world one would envisage an interface design approach which could be accessed by audio alone, by viewing alone, or through a combination of the two (and all under user control).

Another related point is the current overcrowding of visual interfaces. Audio could have a real use here in supplementing the visual interface in a complementary manner.

MAPPING BETWEEN DOMAIN AND MUSIC
The key issue in using music in interface design is how to map between domain entities and procedures, and equivalent musical structures. To investigate this we have carried out experiments on using pitch, timbre, rhythm and melodies. Users competence at recognizing pitch intervals, and different timbres has been determined. The results suggest that, provided precise numerical relationships are not being communicated, music can transfer information successfully. We have been particularly concerned with the mapping for subjects who have had no special musical training.

USING MUSIC FOR ALGORITHM AURALISATION
We have implemented a number of sorting algorithms and path following algorithms using music alone (this distinguishes the work from that of Brown and Herchberger [5] who supplemented the visual output with sound). We

have also measured how successfully the algorithm activity is communicated via the music

USING MUSIC IN PROGRAM OR ALGORITHM DEBUGGING

The use of music in algorithm auralisation also suggests another possible use - that of program debugging. In a sense the application is the same The algorithm being auralised is simply faulty.

The possibility of using musical output for debugging has already been suggested by Francioni [9] for debugging a parallel processor message system. They point out that the musical representation can highlight situations which could easily be missed in the visual representation (no doubt there are also cases in the reverse direction). For example, a move of one semitone of a note in a musical chord can change the whole sense of that chord and produce an immediate and compelling effect. A similar movement in the value of one data variable in a graph might not be noticed. Bock [11] has developed an Auditory Domain Specification language which has been used in debugging.

In the programming language debugging situation, the richness provided by a musical representation can offer fairly precise bug location possibilities (whether used in isolation or in conjunction with the visual media). One obvious possible mapping is to map the tracing of the execution path through different modules to different instruments. This is an area which is not handled well by visual media, causing frequent screen shifts. Using timbre, the switches between modules are capable of being followed easily, allowing the visual sense to concentrate upon program detail.

We believe that music can also be used for language debugging. We have constructed a PASCAL preprocessor (CAITLIN - Computer Audio Interface to Locate Incorrect Nonesense [10]) which maps PASCAL constructs to particular musical structures. A FOR-NEXT loop for example is mapped to a rising pitch based upon the loop variable. REPEAT-UNTIL and REPEAT-WHILE loops are distinguished by a simple comparison at either the start or the end of the loop. An IF THEN clause is mapped to distinctive timbre and pitch so that the subsequent path can be clearly identified.

Early experimentation with the system has shown that users can distinguish the different constructs.

COMMUNICATING GRAPHICAL INFORMATION TO BLIND USERS

The third area in which we have investigated possible uses of music is in communicating graphical information to blind users. The graphical area is defined in terms of coordinated which are communicated via sequences of ascending pitch. All graphcal objects are communicated via musical sequences which reflect their shape, and all the graphical controls are musical in nature.

The system, called the AUDIOGRAPH, has been developed from feedback from a number of blind users and the initial results are encouraging.

REFERENCES

[1] Bly,S., (1982), Presenting Information in sound. *Proc. CHI'82 on Human Factors in Computer Systems*, pp 371 - 375

[2] Gaver, W., (1986), Auditory Icons: Using Sound in Computer Interfaces, *Human Computer Interaction*, Vol. 2(1)., pp. 167 - 177.

[3] Blattner M., Greenberg, R.M., and Kamegai, M., (1992), Listening to Turbulence: an Example of Scientific Audiolisation, in *Multimedia Interface Design*, (Blattner, M., and Dannenberg, R.M., eds.) , Chapter 6, pp. 87 - 102, Wokingham: ACM Press.

[4] Gaver, W., (1989), The Sonic finder: an interface that uses Auditory Icons, *Human Computer Interaction*, Vol. 4(1), No. 1, pp. 67 - 94.

[5] Brown, M.H., and Herchberger, J., (1992), *Colour and Sound in Algorithm Animation*, IEEE Computer, December, 1992, pp. 52 - 63.

[6] Mansur, D.L., Blattner, MM., and Joy, K.I., (1985), Soundgraphs: A Numerical Data Analysis method for the Blind, *Proc. 18th Hawaii Conf. on System Sciences*, Vol. 18, pp 163 - 174.

[7] Mezrich J.J., Frysinger, S., and Slivjanovski, R., (1984), Dynamic Representation of Multivariate Time Series Data, *J. Am. Statistical Soc.*, Vol. 79, No. 385, pp. 5.22 - 5.28.

[8] Alty, J.L., (1995), Can we use Music in Human computer interaction ? in *People and Computers X*, Diaper, D., and Winder, R., (eds.), Cambridge University Press. pp 409 - 423.

[9] Francioni, J.M., Albright, L., and Jackson, J.A., (1991), Debugging Parallel Programs Using Sound, *SIGPLAN Notices*, Vol. 26 (12), pp. 68 - 75.

[10] Alty, J.L.and Vickers, P., (1996), CAITLIN: A Musical Program Auralisation Tool to assist Novice Programmers with Debugging, to appear in Proceedings.ICAD'96.

[11] Bock, D.S., (1994), An Auditory Domain Specification Language for Program Auralisation", 2nd Int. Conf. on Auditory Display, ICAD'94, Santa Fe, New Mexico, USA.

Demonstration Scenarios

The demonstration will consist of a mix of experiments in which attendees can take part, to convince them that music can indeed be used as an output medium. Most people are sceptical about using music

in HCI, so allowing them to "do and hear" should convince them and allow us to gather further data and opinions on the issue. Thus the demonstration at CHI97 will be partly collecting more data on human musical structure appreciation (pitch leaps, timbre changes, rhythm changes etc..) and partly on showing people the strengths and weaknesses of the approach.

The demonstrations will be as follows:

1. Demonstrations of sorting algorithms using a carefully constructed musical mapping.

Users will first be asked to participate in listening to the audiolised algorithm and will provide feedback on how much they understood. Then an explanation of how the musical mapping was achieved will be given. Alternative mappings will be demonstrated.

2. The CAITLIN Musical Auralisation program

A short introduction to the system will be given. Users will then be briefly trained on the musical mappings used for typical PASCAL constructs. Then a set of tests will be given to demonstrate the recall on short program. Finally a programming debugging exercise will be demonstrated.

3. The AUDIOGRAPH system

The facilties of the system, including graphical object representation, coordinate and cursor representation, and the representation of control actions will be demonstrated together with an explanation of the musical mappings.

Then users will be able to use the system and provide criticism and observations of its performance.

4. General experimentation on use of pitch, timbre and rhythm

Users will be able to take part in experiments to show their capabilities in assimilating musical information. Experiments will include:

- Determination of pitch intervals
- Recall of Timbre
- Recognition of Timbre
- Recall of melodic lines
- Major and minor scale recognition