Metamusical Composing With Computers

David Worrall

The general availability of powerful personal computers makes it possible for those interested in composing to explore many different ways of working with sonic (and visual) materials. The computer can not only be used as a recorder of one's ideas in the traditional "dots on paper" or MIDI sequence approach but can also be used in other more exploratory ways, from a "composer's pocket calculator" to a collaborator in the creative process itself. So, whilst calculation as such is not a new compositional technique (Western music from all historical periods abounds with examples), the computer can support it's use in composition to an extent not previously possible and/or practicable.

I call this latter type of composing, *Procedural* (see [Worrall, 1994]) because in composing in this way one is concerned with designing procedures which a computer can implement in order to generate the composition (or perhaps part of it) - be it a score, a MIDI sequence or the sounds themselves. This is a sort of the metamusical, "top down", more holistic approach than other traditional more direct or through-composed methods.

The use of these procedural techniques is of course not just a technical issue: it encourages the exploration of new relationships between structure, form and content and in doing so, strengthens one's ability to explore unfamiliar aesthetic territory for new compositional ideas.

"Mathophobia" and the Creative Process

Many structures and structuring techniques for making music can be considerably developed with ideas from mathematics and explored with the aid of a little mathematical technique. Much of serial music, for example, can be more deeply understood through group theory; Peano's axioms for the construction of number systems apply equally to the construction of scales of perceptual parameters (duration, pitch, colour etc) and we can explore many different algebras for mapping a-temporal structures into temporal constructions, including some that have no historical connection with music such as those found in genetics or crystallography or neural networks for example.

People who can demonstrate their computational skill through symbolic notation are traditionally considered good at mathematics, yet there are many creative individuals whose conceptualisation skills are highly developed but whose skills with symbolic notation remain poor. These people frequently develop "mathophobia" early in their education and are then judged to be poor at mathematics. Many discontinue their mathematics education as early as possible and, to protect their self-image, profess pride in their ignorance of mathematics. This is such a common problem that I once somewhat provocatively suggested [Worrall, 1992] that if mathematics was not a compulsory study in schools and teachers had justify their own existence by generating student numbers in the way music teachers frequently have to, perhaps more interesting and integrative ways of learning mathematics would be found!

A Study in Design Structures

In an effort to overcome these problems and dilemmas in a practical way, Stuart Ramsden, my animator colleague at the Australian Centre for the Arts and Technology (ACAT) at the ANU, and I to created a *Design Structures* course which we have been teaching (and continually refining!) for the past six years. This course then, has evolved out of our own creative work in algorithmic and procedural composition and a collection of unconnected projects given to composition students over the last fifteen or so years.

There has been a great deal of interest in our course and so, in the hope that it will encourage more people to explore and experiment with such fertile material, I've provided a brief description of some of the features of the course.

There is a basic premise on which our exploratory study (perhaps plunder would be a more accurate description!) of the mathematical literature is based: that it is not necessary to be able to manipulate mathematical notations to understand the concepts which are embedded in this notation. We live in an age where machines can compute much more quickly and reliably than humans. (Someone once calculated that the first Macintosh computer (1984) could perform all the calculations that Newton had done in his lifetime in 11 seconds - and much more accurately!) Why then is mathematics still taught as if it is primarily an exercise in computation? Especially as we know from experience that if students are encouraged to develop their own conceptual methods of understanding mathematical ideas, no matter how unconventional, then they can sustain a higher level of reasoning with these ideas; in short, of mathematicising.

Design Structures then, explores mathematical ideas for experimental music and animation composition in a non-trivial way. It develops in the student an understanding of mathematical structures and procedures from their conceptual and foundational frameworks. In using computers for integrating these ideas with sound and image, composers are able to generates experience in visual art and music based on a wide range of structuring principles.

An important part of the whole process is to maintain a clarity of vision for why the studies are undertaken in the first place. Whilst many of the topics are quite technical, an underlying principle of the course is the development of aesthetic sensibilities together with technique. This principle ensures that the presentation of the material is moderated by artistic rather than purely computational concerns. This helps students to contexturalise mathematical thinking both as a way of encouraging reasoning with aesthetic principles and as practical tools for making art (in our case, with computers). This, what we might call a "perceptual approach" to teaching mathematical principles, draws students to mathematics of a certain depth, complexity and generality, that would not be possible if the approach was computational, and it is this depth and beauty of patterning which makes the mathematics manifest - sometimes in unexpected ways.

Teaching Methods

As outlined in the accompanying diagram, students undertaking the course engage in three main activities; the first two are undertaken in parallel and lead naturally onto the third:

1. Reading material from books and journals, video and animation as well as music have been collected over many years. This material is being continually updated when a new article etc with an appropriate approach is located or additional material is produced by the staff to further clarify a concept. Appropriate written material from this collection is reviewed by students before each seminar which is a discussion of the topic with examples drawn from the mathematical, music and visual literatures. It is our intention to eventually produce a stylistically integrated (hyper)text and compositional environment with graduated exercises.

2. Learning to use a high-level interpretive programming language for symbol, image and sound manipulation leads to a graduated practical exploration of the ideas with a computer. The importance of this activity is based on understanding that the need for the artists to program the computer themselves is fundamental to the exploratory process. As the animator John McCormack has said [McCormack, 1994]:

    > Inevitably, to really exploit and understand the process I am referring to, you must write your own software. This puts you on more basic terms with the machine, it allows the direct implementation of ideas, as opposed to interpretation through another's constraints (p. 23).

    The choice of programming language is thus very important. In the initial assignments we currently use APL (see especially [Iverson, 1980]) because it is:

    - a very high level language, thus reducing the need for a major time investment in basic tool development;
    - interpretive. By replacing the compile-link-run (-crash!) cycle with a "what you see is what you get" interface, it supports the student's need to explore different approaches and solutions by encouraging examination of the output of each step of a process along the development path;
    - designed for mathematics, and is particularly strong for set and multidimensional matrix manipulation;
    - has many very powerful primitive operators for the easy manipulation of data in sophisticated ways.

3. Production of a work using principles and techniques learned in 1. and 2. Students complete a number of set assignments and then undertake their own (individually tutored) creative explorations of a topic or combination of topics of their choice.

Conclusion

We continue to experiment with new ways of exploring mathematical ideas for sound and image composition, and how and when to use different representational symbols, graphs, maps, and models. In doing so, we are finding alternatives to the dogma of serialism, and/or "chance" operations which all-too-quickly replaced the dogma of functional harmony in many composition courses; alternatives to studies in navel-gazing post-modernism in visual arts courses where the computer is simply a "modern" tool with which to realise The Work. We are exploring new ways for students to develop compositional techniques in which the computer is a more of a collaborator in exploring new paradigms compositionally more fecund than species counterpoint and mobile form; ideas such as fuzzy logic, fractals, L-systems, genetic algorithms and emergent behaviour.

Summary of our approach to teaching *Design Structures.*

Bibliography

Iverson, K. (1980) "Notation as a Tool for Thought." The 1979 ACM Turing Award Lecture. Communications of the ACM 23, 8.

McCormack, J. "Wild. An Interactive Computer Installation"(pp. 22-24). 1994 Next Wave Art & Technology Catalogue.

Worrall, D (1990). "Pinocchio's Journey. On Teaching Music Composition". Proceedings of the Australian New Music Conference, August 1990, Brisbane.

Worrall, D (1992). "Design Structures: A Course in the Fundamentals of Mathematics and their Applications to Sonic and Visual Composition". Proceedings of the 2nd Bridging Mathematics Conference July 1992 ANU, Canberra.

Worrall, D. (1994). "Procedural Composition: An Overview". Proceedings of Synaesthetica '94 .Symposium Canberra: ACAT Publication.

Worrall, D. (1995). "Studies in Metamusical Methods for Sound and Image Composition". Proceedings of 1995 Australian Computer Music Conference, Australian Computer Music Association, July 1995, Melbourne.