New Course Proposal

Introduction to Computer Music and Sound Synthesis

Tamara Smyth
School of Computing Science
Simon Fraser University, Surrey
tamaras@cs.sfu.ca

January 26, 2006

1 Calendar Information

Course Number: CMPT 368

Course Title: Introduction to Computer Music and Sound Synthesis.

Credit Hours: Three (3) hours of lecture per week.

Course Description An introduction to the fundamentals of digital audio, computer music, basic sound synthesis algorithms, and digital audio effects and processing. Topics include concepts of sound and digital audio representation, basic concepts of digital filtering, fundamentals of spectrum analysis, and sound synthesis techniques. Understanding of theoretical concepts will be consolidated through practical programming assignments in Matlab, however there will also be exposure to various freeware real-time audio programming and sound editing environments.

Prerequisites: MATH 152 and one of CMPT 125, 126 or 128 (or permission of instructor).

2 Rationale for Introduction of this Course

Computerized sound/music is a growing area of research and interest, but until recently, has not been given the same attention as graphics and animation within university level

computer science and engineering programs. This trend is beginning to change however, as we begin to see leading universities in the United States: Stanford, Princeton, Harvard, MIT, Carnegie Mellon, Brown (to name just a few), offering programs (and in some cases complete degree concentrations) in this area.

Like the field of computer graphics and animation, computer sound is inherently mathematical, demanding a similarly in-depth, theoretical understanding of both users and research/developers practicing in the field. Though we have seen several audio courses being offered within many liberal/fine arts programs, usually for incorporating into various new media and music projects, courses providing a more rigorous mathematical foundation are decidedly lacking from computer science and engineering programs.

Will this be a required or elective course in the curriculum? This will be an elective course (at least initially) until an area of concentration can be established.

Probable enrollment when offered? When offered as a special topics class at Surrey, Spring 2005, enrollment was initially at 23, with a mixture of SIAT and CMPT students. After two (2) weeks, the SIAT contingent dropped (allegedly because they found the class more technical than they had expected). Enrollment then stabilized at 10 students, most of whom were from Computing Science, and all of whom were travelling from Burnaby.

This implies that there is a demand and need for a more technically rigorous audio course within the School of Computing Science. It is also evident that such a course would not overlap, nor be redundant to, any offered by SIAT. Prediction of enrollment for non-required classes at the still new Surrey Campus is difficult, but evidence shows that enrollment for such a course could be relatively high.

3 Scheduling and Registration Information

Indicate Semester and Year this course would be first offered and planned frequency of offering thereafter: Fall 2006 and annually thereafter. This would clear the way for a second continuing class in the Spring semester, should the first prove successful.

Which of your present CFL faculty have the expertise to offer this course? Tamara Smyth, Assistant Professor in the School of Computing Science, will design, develop and instruct the course.

Current faculty exist to teach this course: Tamara Smyth.

Are there any proposed student fees associated with this course other than tuition fees? The only cost incurred by the student enrolling in the course will be that of the textbook (which will eventually go away as the course notes become more complete). Matlab is made available to all students in the computer labs at SFU-Surrey (and Burnaby), though they may *choose* to purchase a student version for their personal computer (at approximately the price of a textbook). There is also the alternative for students to use Octave, a freeware version of Matlab (which is sufficient for implementing algorithms discussed in class). All other software selected for class use is freeware, and as such will be of no cost to the student.

Is this course considered a "duplicate" of any current or prior course under the University's duplicate course policy? Though this class may complement others offered in Communications and SIAT at SFU, it does not duplicate them as it presents the theoretical foundations much more rigorously.

It also in no way duplicates Signal Processing classes (which are broader in scope) within the School of Engineering Science. Rather, it will introduce certain concepts of signal processing which are necessary to understand and implement algorithms for sound synthesis and audio effects processing.

It should also be emphasized that this is not a class in audio coding or compression techniques, and though students will be presented with perceptual issues related to computation, it will be within a context of *analysis and synthesis*.

4 Resource Implications

Note: Senate has approved (S.93-11) that no new course should be approved by Senate until funding has been committed for necessary library materials. Each new course proposal must be accompanied by a library report and, if appropriate, confirmation that funding arrangements have been addressed. There are already substantial and sufficient library resources in place.

Provide details on how existing instructional resources will be redistributed to accommodate this new course. For instance, will another course be eliminated or will the frequency of offering of other courses be reduced; are there changes

in pedagogical style or class sizes that allow for this additional course offering. NA.

Does the course require specialized space or equipment not readily available in the department or university, and if so, how will these resources be provided? It would be preferable to teach this course in a room somewhat more acoustically insulated than what is currently available in the SFU Surrey Beta Space (though this point should not be an issue as we are planning to move in the Summer before Fall 2006). The classroom should be equipped with studio quality monitors, and such classrooms will be available at SFU Surrey.

Does this course require computing resources (e.g. hardware, software, network wiring, use of computer laboratory space) and if so, describe how they will be provided. Headphones (already purchased) will need to be installed on selected terminals in the computer labs (already available) at Surrey. We will also need to equip the same computer terminals with quality audio interfaces (for which there is already established funding).

5 Course Outline

- **Week 1: Introduction to Computer Music and the Class**
  - The field, the players; Sound demonstrations.
- **Week 2-3: Fundamentals of Acoustics, Sounds and Digital Audio**
  - *What is sound?* Travelling waves (longitudinal, transverse); physical quantities of a waveform; hearing; sound power, intensity and pressure levels (SPL) and decibels (dB)
  - *Fundamentals of Digital Audio.* Analog to digital conversion; Sampling (Nyquist sampling theorem); Aliasing; Quantization.
- **Week 4-6: Spectral Representation**
  - *Sinusoids.* Why sinusoids are important; Amplitude, phase and frequency; Sinusoids and physical motion; Sinusoids and circular motion; Adding sinusoids.

  - *Complex Sinusoids and the Discrete Fourier Transform (DFT).* Exponentials; Complex Numbers; Euler's Formula; Complex Exponential Signals; Phasors; Spectral representation and the DFT.

- **Week 6-9: Sound Synthesis Techniques**
  - *Additive Synthesis.* Creating signal generators and more complex waveforms; Signal generators; Analysis and synthesis.
  - *Amplitude Modulation.* Ring modulation; "Classic" amplitude modulation; Beating (beat notes); Modulator and carrier frequencies; AM spectrum.
  - *Frequency Modulation.* Linear FM ("chirp" signals); Vibrato simulation; Carrier and modulating oscillator networks; Instrument examples; FM spectrum.
  - *Waveshaping Synthesis.* Linear Interpolation; Thru box, inverter and attenuator; Transfer functions; Calculating spectral Output
- **Week 10-11: Subtractive Synthesis and Digital Filters**
  - *Sound sources:* noise, pulses.
  - *Filters:* low-pass, hi-pass, bandpass, bandreject; Delay; Simple digital FIR and IIR derived; Cascade connections.
  - Impulse Response; Convolution; Implementation.
- **Week 12: Delay Effects and Artificial Reverberation**
  - Flanging; Phaser (phase shifter); Fractional delay; Chorus effect; Karplus-Strong algorithm for a plucked string.
  - Reverberation; Reverb time; Comb filters; All-pass filters; Networks of unit reverberators.
- **Week 13: Project Presentations**

6 Texts, Resources and Materials

- Tamara Smyth. *Course Notes for CMPT 318*, web publication in progress since January 2005.
- Charles Dodge and Thomas A. Jerse. *Computer Music: Synthesis, Composition, and Performance*, 2nd Edition, Wadsworth Publishing, 1997.

- Perry R. Cook. *Real Sound Synthesis for interactive Applications*, A. K. Peters, 2002.