MUCP 5690: Topics in Electroacoustic Music
Delay Based Digital Signal Processing

Instructor: Jon Christopher Nelson, jon.nelson@unt.edu, 940-369-7531
Time and Location: Mondays, Wednesdays and Fridays, 1:00-1:50 PM, Music 2009
Office Hours: email is fastest, meetings arranged as per student request

OBJECTIVES:

Delay Based Digital Signal Processing will focus on computer music techniques based on signal delays, including digital filters, effects, and extensive coverage of physical modeling techniques. The students will demonstrate their understanding of the materials through both programming assignments and the completion of a final project which can either consist of a significant original composition utilizing class materials (stereo or multi-channel, fixed media or real-time interactive) or the development of software tools based on the class materials. Throughout the course we will work together to develop a variety of shared software tools that can be utilized in future compositional and research endeavors.

GRADING:

Final course grades will be determined according to the following formula:

- 60% class participation (attendance, class discussion, assignments, tests)
- 40% final composition/research project

ATTENDANCE/CLASSROOM COURTESY:

Attendance is expected and factors into the class participation component of the grade. Out of courtesy to others, please make every effort to arrive at class on time. If you must miss a class, it is your responsibility to find out about any missed materials. More than two unexcused absences will result in the final grade being docked one full letter grade.

CLASS PARTICIPATION:

Students are expected to come to class prepared, having read the required readings and prepared assignments. Assignments listed for a class date must be completed BEFORE the class begins. Participation in classroom discussion will be a primary factor for demonstrating class preparation. Assignments may include, but will not be limited to quizzes, programming assignments (primarily Max/MSP and Csound, but may also include other software),audio production exercises, and listening. Students will post assignments at http://www.music.unt.edu/comp/jcnelson/DBDFX

FINAL PROJECT:

The final project will consist of one of the following: 1) an electroacoustic composition of 8-12 minutes duration that makes extensive use of physical modeling techniques and exhibits pristine audio production technique as well as a carefully wrought formal structure or 2) a programming project to develop a suite of software tools as per instructor approval. With instructor consideration and approval, group projects may also be proposed.

CLASS WEB SITE: blackboard https://learn.unt.edu and http://music.unt.edu/comp/jcnelson/DBDSP

LIBRARY RESERVE MATERIALS:

C. Roads, *the Computer Music Tutorial*. Cambridge, Massachusetts: The MIT Press, 1996.

P. R. Cook. *Real Sound Synthesis for Interactive Applications*. Natick, Massachusetts: Peters, A K, Limited, 2002.

R. Boulanger, ed., in *The Csound Book*. Cambridge, Massachusetts: The MIT Press, 2000. (also available through UNT library electronic resources)

M. Puckette. *The Theory and Technique of Electronic Music*. New Jersey: World Scientific, 2007. THIS BOOK CAN BE FOUND ONLINE AT: http://crca.ucsd.edu/~msp/

U. Zölzer, ed. *DAFX Digital Audio Effects*. West Sussex, England: John Wiley & Sons Ltd., 2002. (also available through UNT library electronic resources)

G. Loy. *Musimathics vol. 2.* Boston, Massachusetts: MIT Press, 2007.

RECOMMENDED MATERIALS BY TOPIC:

General Computer Music Theory:

C. Roads, *the Computer Music Tutorial*. Cambridge, Massachusetts: The MIT Press, 1996. (on reserve)

Digital Signal Processing:

R. Allred. *Digital Filters for Everyone*. Indian Harbor Beach, Florida: Creative Arts and Sciences House, 2010.

J. Broesch. *Digital Signal Processing Demystified*. Solana Beach, California: HighText Publications, 1997.

K. Steiglitz. *A Digital Signal Processing Primer*. Menlo Park, California: Addison-Wesley Publishing Company, 1995.

S. Templaar. *Music Signal Processing*. Exton, Pennsylvania: Swets, 1996.

U. Zölzer, ed. *DAFX Digital Audio Effects*. West Sussex, England: John Wiley & Sons Ltd., 2002. (on reserve) (available through UNT library electronic resources)

http://www.dafx.de/ This is the DAFX annual conference web site with PDFs of all conference papers. The site contains many articles on both DSP and Physical Modeling.

Physical Modeling:

P. R. Cook. *Real Sound Synthesis for Interactive Applications*. Natick, Massachusetts: Peters, A K, Limited, 2002. (on reserve)

J. O. Smith, *Physical Audio Signal Processing*. December 2008 ed., Stanford, California: W3K publishing, 2008. THIS BOOK CAN BE FOUND ONLINE AT: http://www.dsprelated.com/dspbooks/pasp/

J. O. Smith. *Introduction to Digital Filters.* Stanford, California: W3K publishing, 2007. THIS BOOK CAN BE FOUND ONLINE AT: http://www.dsprelated.com/dspbooks/filters/

L. Trautman and R. Rabenstein. *Digital Sound Synthesis by Physical Modeling Using the Functional Transformation Method*. New York: Kluwer Academic/Plenum Publishers, 2003.

V. Välimäki, J. Pakarinen, C. Erkut and M Karjalainen. *Discrete-Time Modeling of Musical Instruments*. Online. IOP Publishing Limited, 2006. http://stacks.iop.org/RoPP/69/1

Max/MSP/Jitter:

A. Cipriani and M. Giri, (D. Stutz trans.). *Electronic Music and Sound Design.* Rome, Italy: ConTempoNet, 2010.

V. J. Manzo. *Max/MSP/Jitter for Music.* New York: Oxford University Press, 2011.

Csound:

R. Boulanger, ed., in *The Csound Book*. Cambridge, Massachusetts: The MIT Press, 2000. (on reserve)

R. Bianchini and A. Cipriani. *Virtual Sound.* Rome, Italy: ConTempoNet, 2011.

A. Horner and L. Ayers. *Cooking with Csound Part 1: Woodwind and Brass Recipes.* Middleton, Wisconsin: A-R Editions, Inc., 2002.

PD (Pure Data):

M. Puckette. *The Theory and Technique of Electronic Music*. New Jersey: World Scientific, 2007. (on reserve) THIS BOOK CAN BE FOUND ONLINE AT: http://crca.ucsd.edu/~msp/

A. Farnell, *Designing Sound*. London, England: Applied Scientific Press, 2006.

SuperCollider:

S. Wilson, D. Cottle, and N. Collins, eds. *The SuperCollider Book.* Cambridge, Massachusetts: MIT Press, 2011

Mathematics:

G. Loy. *Musimathics, vol. 1.* Boston, Massachusetts: MIT Press, 2006. (available through UNT library electronic resources)

G. Loy. *Musimathics vol. 2.* Boston, Massachusetts: MIT Press, 2007. (on reserve)

O. Bishop. *Understand Electrical and Electronics Math.* Boston: BH Newnes, 1993.

M. Kline. *Mathematics for the Non-Mathematician.* New York: Dover, 1967.

Transnational College of LEX. *Who Is Fourier?* Boston: Language Research Foundation, 1995.

J. O. Smith. *Mathematics of the Discrete Fourier Transform (DFT*). Stanford, California: W3K Publishing, 2008. THIS BOOK CAN BE FOUND ONLINE AT: http://www.dsprelated.com/dspbooks/mdft/

J. O. Smith. *Spectral Audio Signal Processing.* Stanford, California: W3K Publishing, 2011. THIS BOOK CAN BE FOUND ONLINE AT: http://www.dsprelated.com/dspbooks/sasp/

More Physical Modeling:

J. M. Adrien, "The Missing Link: Modal Synthesis," in *Representations of Musical Signals* (G. De Poli, A. Piccialli, and C. Roads, eds.), pp.269-298, Cambridge, Massachusetts: The MIT Press, 1991.

G. Bennett and X. Rodet, "Synthesis of the Singing Voice," in *Current Directions in Computer Music Research* (M. Mathews and J. Pierce, eds.), pp. 19-44, Cambridge, Massachusetts: MIT Press, 1989.

M. Clarke, "FOF and FOG Synthesis in Csound," in *The Csound Book* (R. Boulanger, ed.), pp. 293-306, Cambridge, Massachusetts: The MIT Press, 2000.

J. M. Comajuncosas, "Analog Dreams: Modeling Commercial Synthesizers," in *The Csound Book* (R. Boulanger, ed.), CD-ROM chapter 20, Cambridge, Massachusetts: The MIT Press, 2000.

J. M. Comajuncosas, "Physical Models of Strings and Plates Using Simplified Mass-String Method," in *The Csound Book* (R. Boulanger, ed.), CD-ROM chapter 21, Cambridge, Massachusetts: The MIT Press, 2000.

N. Fletcher and T. Rossing. *The Physics of Musical Instruments*. 2nd edition. New York: Springer, 2010.

J. L. Florens and C. Cadoz, "The Physical Model: Modeling and Simulating the Instrument Universe," in *Representations of Musical Signals* (G. De Poli, A. Piccialli, and C. Roads, eds.), pp.227-268, Cambridge, Massachusetts: The MIT Press, 1991.

B. Gold and N. Morgan. *Speech and Audio Signal Processing*. New York, New York: John Wiley & Sons Inc., 2000.

E. Lyon, "An Introduction to Reverberation Design with Csound," in *The Csound Book* (R. Boulanger, ed.), pp. 467-482, Cambridge, Massachusetts: The MIT Press, 2000.

H. Mikelson, Implementing the Gardner Reverbs in Csound," in *The Csound Book* (R. Boulanger, ed.), pp. 483-492, Cambridge, Massachusetts: The MIT Press, 2000.

H. Mikelson, Mathematical Modeling with Csound: From Waveguides to Chaos," in *The Csound Book* (R. Boulanger, ed.), pp. 369-388, Cambridge, Massachusetts: The MIT Press, 2000.

H. Mikelson, Modeling A Multieffects Processor in Csound," in *The Csound Book* (R. Boulanger, ed.), pp. 207-222, Cambridge, Massachusetts: The MIT Press, 2000.

H. Mikelson, Modeling Classic Electronic Keyboards in Csound," in *The Csound Book* (R. Boulanger, ed.), pp. 207-222, Cambridge, Massachusetts: The MIT Press, 2000.

E. R. Miranda, "Three Modeling Approaches to Instrument Design," in *The Csound Book* (R. Boulanger, ed.), CD-ROM chapter 27, Cambridge, Massachusetts: The MIT Press, 2000.

X. Serra, "Musical Sound Modeling with Sinusoids Plus Noise," in *Musical Signal Processing* (C. Roads, S. T. Pope, A. Piccialli, and G. De Poli, eds.), pp.91-122, Exton, PA: Swets & Zeitlinger Publishers, 1997.

J. O Smith, "Acoustic Modeling Using Digital Waveguides," in *Musical Signal Processing* (C. Roads, S. T. Pope, A. Piccialli, and G. De Poli, eds.), pp.221-264, Exton, PA: Swets & Zeitlinger Publishers, 1997.

J. O. Smith, ``Principles of digital waveguide models of musical instruments," in *Applications of Digital Signal Processing to Audio and Acoustics* (M. Kahrs and

K. Brandenburg, eds.), pp. 417-466, Boston/Dordrecht/London: Kluwer Academic Publishers, 1998.

J. Sundberg, "Synthesis of Singing by Rule," in *Current Directions in Computer Music Research* (M. Mathews and J. Pierce, eds.), pp. 45-56, Cambridge, Massachusetts: MIT Press, 1989.

J. Sundberg, "Synthesizing Singing," in *Representations of Musical Signals* (G. De Poli, A. Piccialli, and C. Roads, eds.), pp.299-320, Cambridge, Massachusetts: The MIT Press, 1991.

L. Trautmann and R. Rabenstein. *Digital Sound Synthesis by Physical Modeling Using the Functional Transformation Method*. New York, New York: Kluwer Academic/Plenum Publishers, 2003.

J. Wawrzynek, ``A VLSI approach to sound synthesis,'' in *Current Directions in Computer Music Research* (M. Mathews and J. Pierce, eds.), pp. 113-148, Cambridge, Massachusetts: MIT Press, 1989.

A more comprehensive bibliography with more than 500 physical modeling citations can be found at Julius Smith's web site:
https://ccrma.stanford.edu/~jos/pasp/Bibliography.html

Office of Disability Accommodation

The University of North Texas makes reasonable academic accommodation for students with disabilities. Students seeking accommodation must first register with the Office of Disability Accommodation (ODA) to verify their eligibility. If a disability is verified, the ODA will provide you with an accommodation letter to be delivered to faculty to begin a private discussion regarding your specific needs in a course. You may request accommodations at any time, however, ODA notices of accommodation should be provided as early as possible in the semester to avoid any delay in implementation. Note that students must obtain a new letter of accommodation for every semester and must meet with each faculty member prior to implementation in each class. For additional information see the Office of Disability Accommodation website at http://www.unt.edu/oda. You may also contact them by phone at 940.565.4323.

Financial Aid Satisfactory Academic Progress

A student must maintain Satisfactory Academic Progress (SAP) to continue to receive financial aid. Students must maintain a minimum 3.0 cumulative GPA in addition to successfully completing a required number of credit hours based on total registered hours per term. Students cannot exceed maximum timeframes established based on the published length of the graduate program. If a student does not maintain the required standards, the student may lose their financial aid eligibility. If at any point you consider dropping this or any other course, please be advised that the decision to do so may have the potential to affect your current and future financial aid eligibility. Please visit *http://financialaid.unt.edu/satisfactory-academic-progress-requirements* for more information about financial aid Satisfactory Academic Progress. It may be wise for you to schedule a meeting with an academic advisor in your college or visit the Student Financial Aid and Scholarships office to discuss dropping a course being doing so.

Academic Integrity

Academic Integrity is defined in the UNT Policy on Student Standards for Academic Integrity. Any suspected case of Academic Dishonesty will be handled in accordance with the University Policy and procedures. Possible academic penalties range from a verbal or written admonition to a grade of "F" in the course. Further sanctions may apply to incidents involving major violations. You will find the policy and procedures at: http://vpaa.unt.edu/academic-integrity.htm.

Student Behavior in the Classroom

Student behavior that interferes with an instructor's ability to conduct a class or other students' opportunity to learn is unacceptable and disruptive and will not be tolerated in any instructional forum at UNT. Students engaging in unacceptable behavior will be directed to leave the classroom and the instructor may refer the student to the Center for Student Rights and Responsibilities to consider whether the student's conduct violated the Code of Student Conduct. The university's expectations for student conduct apply to all instructional forums, including university and electronic classroom, labs, discussion groups, field trips, etc. The Code of Student Conduct can be found at: www.unt.edu/csrr.

COURSE OUTLINE READING ASSIGNMENT KEY:

The outline below includes a shorthand reference to the reading materials using a capital letter (author's last name) and the chapter number.subsection. Optional readings will be indicated parenthetically. There may be additional PDF reading materials assigned. These will be provided in class or on the class web site.

A = R. Allred. *Digital Filters for Everyone*. Indian Harbor Beach, Florida: Creative Arts and Sciences House, 2010.

B = R. Boulanger, ed., in *The Csound Book*. Cambridge, Massachusetts: The MIT Press, 2000. (on reserve)

C = P. R. Cook. *Real Sound Synthesis for Interactive Applications*. Natick, Massachusetts: Peters, A K, Limited, 2002. (on reserve)

L = G. Loy. *Musimathics vol. 2.* Boston, Massachusetts: MIT Press, 2007. (on reserve)

P = M. Puckette. *The Theory and Technique of Electronic Music*. New Jersey: World Scientific, 2007. (on reserve) THIS BOOK CAN BE FOUND ONLINE AT: http://crca.ucsd.edu/~msp/

R = C. Roads, *the Computer Music Tutorial*. Cambridge, Massachusetts: The MIT Press, 1996.

Z = U. Zölzer, ed. *DAFX Digital Audio Effects*. West Sussex, England: John Wiley & Sons Ltd., 2002. (on reserve) (available through UNT library electronic resources)

COURSE	**OUTLINE**		
Day	**Topic**	**Reading Assignment**	**Programming Assignment**
Aug. 29	syllabus overview		
Aug. 31	software overview, signal diagram transcoding	A1a, B1-3, Z1.2	
Sept. 3	**Labor Day (No Class)**	R1	
Sept. 5	digital audio, sampling, synthesis, delay, multitap delay	B20	
Sept. 7 (trip)	**NO CLASS (Nelson in Slovenia)**	R3-5	
	BASIC FILTER DESIGN:		
Sept. 10	Andrew May Guest Lecture FIR filters, moving average filters	A1b, C3, Z2, R10 (L5, P8)	
Sept. 12	Andrew May Guest Lecture IIR		
Sept. 14	**NO CLASS (Nelson in Slovenia)**		
Sept. 17	Alpha filter, transversal filter, linear phase structure, Nth order FIR and IIR filters, lattices	A2	
Sept. 19	2nd order pole-zero (biquad) filters and tuning algorthms		5th order FIR lattice filter
Sept. 21	Nth order general pole-zero filter and tuning algorithms		Final Project Proposals Due
Sept. 24	FIR and IIR comb filters, Universal Comb Filter	Z3	4th order IIR filter
Sept. 26	1st order allpass filters and 2nd order allpass (lattice) filters		6 parallel Universal Comb Filters
Sept. 28	2nd order band pass/band reject filters and 1st and 2nd order low/high shelving filters		3rd order allpass filter
Oct. 1	State Variable Filter, Noise Reduction Filter		2nd order shelving filter
	TIME-VARYING FILTERS:		
Oct. 3	Wah-wah pedal and time-varying band pass filters, Vibrato, Chorus, Echo		SVF
Oct. 5	Phasers (several versions), stereo phaser and rotary speaker	B10	5 parallel BP filters (time variable)
Oct. 8	Generalized Delay-based effects using comb filters (resonator, flanger, chorus, slapback, echo)	B22, B30	Phaser with 5 allpasses in series
Oct. 10	General multiband effects structure		Stereo Generalized Effects

Oct. 12	Vocal formants using subtractive synthesis, linear prediction	C7-8, Z9	8 band effects module (effect of your choice)
	REVERBERATION:		
Oct. 15	Moorer Reverb, Freebverb, Shroeder-Moorer Reverb	B23-24, Z6.5, R11 (P7)	
Oct.17	Rev~ and my ChangeRev		Schroeder-Moorer Reverb
	NON-LINEAR EFFECTS:		
Oct. 19	RM, FM, AM, feedback AM, feedback FM	R6, C10	Final Project Reports
Oct. 22	Waveshaping and amplifier modeling		
	DYNAMICS PROCESSING:		
Oct. 24	Overview of dynamics processing	Z??	waveshaper
	PHYSICAL MODELING:		
Oct. 26	Analog oscillators and saturation	R7	
Oct. 29	Basic string models and basic Waveguide	C9 (L7, L9.7)	Model of 3-oscillator analog synth
Oct. 31	Plucked string (via delays, filters, and scattering junctions) and String stiffness	B19	Basic waveguide
Nov. 2	Point Mass on string, piano hammers, 3D waveguide, and Electric Guitar (amp with feedback)		Waveguide with movable scattering junction
Nov. 5	Bowed string and friction	C14	Electric Guitar
Nov. 7	Flute		
Nov. 9	Bottle	C11	Flute
Nov. 12	Clarinet (two models)		
Nov. 14	Brass		Clarinet
Nov. 16	Meta-Instrument for winds/strings	(Cook PDF)	Brass
Nov. 19	Banded Waveguides for rigid bars	(Essl PDF)	
Nov. 21	Waveguide meshes with scattering junctions	C12	6 banded waveguides
Nov. 23	**Thanksgiving Break (No Class)**		
Nov. 26	Other instruments		3x5 mesh wrapped
Nov. 28	Other instruments		
Nov. 30	Projects		
Dec. 3	Projects		
Dec. 5	Projects		
Dec. 7	**Reading day (no class)**		
Dec. 12 (Wed.)	**FINAL project 10:30 AM-12:30 PM**	**MEIT**	