Teachers

- Vesa Välimäki, course lecturer
  - Professor of audio signal processing at the Dept. of Signal Processing and Acoustics
  - Research interests: filters, audio effects processing, headphone audio, sound synthesis, musical acoustics
- Benoit Alary, course assistant
  - Doctoral candidate at the Dept. of Signal Processing and Acoustics
  - Research interests: artificial reverberation, virtual acoustics, spatial audio, VR audio
  - Contact: ELEC-E5620@aalto.fi
General Description of the Course

• A second course on DSP or a postgraduate course
• Course material and lectures in English
• Methods and applications of digital audio signal processing concentrating on musical signals and noise but excluding speech
• Methods needed in research and industry
• All lectures during periods III and IV
• Use WebOodi for registration (IMPORTANT!)
  – Registration will be closed on Monday, Jan. 14 at 23:59!!!
• Use MyCourses to access slides and submissions folder (https://mycourses.aalto.fi/course/view.php?id=20944).

Previous Course Feedback & Changes

• We receive very positive feedback from students every year
  – Award for High-Quality Teaching in 2016-2017!!!
• Average score in 2018: 4.0 (in 2017: 4.88)
  – “Best course so far!”, “Great course staff, lecture content & project topics”
• No severe criticism
  – “Slightly too large” workload: 3.5 (“Just right” would be 3.0)
  – “A bit more relaxed timetable would have helped”
  – “Would be good to have more examples of what MATLAB implementation we could do”
• Minor adjustments in 2019
  – More even distribution of workload, esp. homework assignments.
  – More MATLAB examples will be shown
  – Lectures and demo topics have been updated (as we do every year).
Prerequisites

• Must be familiar with basics of acoustics and DSP, such as:

  1) ELEC-5600 Communication Acoustics (5 cr)

  2) ELEC-C5230 Digital Signal Processing Basics (5 cr)

  or equivalent knowledge

• Contact Vesa or Benoit, if you are unsure!
Course Schedule for 2019 (Periods III-VI)

0. General issues (Vesa & Benoit) 11.1.2019
1. History and future of audio DSP (Vesa) 18.1.2019
2. Digital filters in audio (Vesa) 25.1.2019
3. Audio filter design (Vesa) 1.2.2019
4. Analysis of audio signals (Vesa) 8.2.2019
5. Audio effects processing (Benoit) 15.2.2019
* No lecture (Evaluation week for Period III) 22.2.2019
6. Synthesis of audio signals (Fabian) 1.3.2019
7. Reverberation and 3-D sound (Benoit) 8.3.2019
8. Physics-based sound synthesis (Vesa) 15.3.2019
9. Sampling rate conversion (Vesa) 22.3.2019
10. Audio coding (Vesa) 29.3.2019

Homework Schedule

<table>
<thead>
<tr>
<th>Homework</th>
<th>Handout date</th>
<th>Due date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework 1 (short)</td>
<td>11.01.2019</td>
<td>17.01.2019 (16:00)</td>
</tr>
<tr>
<td>Homework 2</td>
<td>25.01.2019</td>
<td>06.02.2019 (16:00)</td>
</tr>
<tr>
<td>Homework 3</td>
<td>15.02.2019</td>
<td>06.03.2019 (16:00)</td>
</tr>
<tr>
<td>Homework 4</td>
<td>15.03.2019</td>
<td>27.03.2019 (16:00)</td>
</tr>
<tr>
<td>Homework 5 (short)</td>
<td>29.03.2019</td>
<td>05.04.2019 (16:00)</td>
</tr>
</tbody>
</table>
Goals:
After the course you will be able to…

…describe the history, trends, and development of digital ASP
…recognize and design digital filters used in ASP
…list sound analysis and synthesis methods and their main features
…list audio effects processing techniques and their main characteristics
…explain how different kinds of audio codecs can be used
…describe what the concepts ‘virtual acoustics’ and ‘3-D sound’ means
…apply the provided tools with MATLAB in your demo assignment

Learning Methods

• Participate in the lectures and make notes
• Concentrate on the big picture instead of every small detail
• Learning takes time! → Plan your use of time
• Study literature: some good articles are provided on the course web site and as references
• Be active, ask questions
Course Requirements: Two Options

Option #1 (Active): Demo & learning diaries & homework
− Attend all lectures and be active
− Learning diaries and homework replace the exam

OR

Option #2 (Passive): Demo & exam
− Not obligatory to attend all lectures, but must prepare and present a demo!
− Three exams within a year. First chance: Monday, May 13, 2019

Note: everyone has to make a demo, i.e. course project.

Demo: Course Project

- Mandatory for everybody: 50% of the course workload and grade
- Done in two-person teams
- The end result must include audible sound and visualizations
- It takes a few weeks to prepare a demo
- Demos will be presented as part of lectures (1-3 demos per week)
Learning Diaries (Option #1)

• Short essays (1-2 pages) based on your lecture notes, containing for example
  – Highlights of the lecture
  – What you learned
  – New ideas or insights?
  – What was difficult
  – Study web links
  – Try something out with MATLAB, include plots or links to your processed audio files
  – Anything extra you wish to share related to the lecture

Learning Diaries (cont’d)

• Write the learning diaries like essays
  – Do not copy sentences from the slides or from the web
  – Use your own words – Plagiarism is absolutely forbidden!
  – Cite references (e.g. articles and web pages)
• Focus on quality, not quantity!
• Write only in English please
• Example of an excellent learning diary
Requirements for Learning Diaries

- Return 10 learning diaries, one per lecture (min 8)
  - Not required for lecture #0 (this lecture)
  - If you must be absent, write an extended diary (max 2). Please contact Benoit before submitting an extended diary.
- Deadline: Next Thursday after the lecture at 16.00
  - Go to ‘Assignments’ on the top right menu, there will be a return box for each diary.
  - You can submit as many times as you like up until the deadline.
  - Submission grades will be available from the same return box.
- Grading: 0-2 points each
  - Max: 10 × 2 = 20 points
  - Min: 8 × 1 = 8 points

Evaluation of Learning Diaries

- For diaries, you will get 0, 1, 1.5, or 2 points
  ✓ 2 points means that the diary was of acceptable length, has good content, and a MATLAB example is shown.
  ✓ 1.5 points: sufficient length and good content.
  ✓ 1 point is awarded for work that is acceptable but too short, late (<1 week), or otherwise below the standard.
  ✓ 0 points: not acceptable, very late or is missing.
Homework Tasks (Option #1: Active)

- Return 5 homework solutions during the course
  - All 5 required to pass the course
- Instructions and deadlines will be on MyCourses
- Grading: 0-2 points
  - 2 points is very good, 1 point is accepted, and 0 points means that you need to do better
  - Max: $5 \times 2 = 10$ points
- Total max points = 20 (diaries) + 10 (homework) = 30 p.
  - By taking the exam, max 30 points can also be gained
  - Max grade for the demo is also 30 points

File Upload

- Use MyCourses to submit homework and diaries
  - A return box for every submission will appear in the ‘Assignments’ section.
Exam (Option #2: Passive)

- Alternative to the learning diaries and homework
- Study the lecture slides and literature provided in MyCourses
  - You will still have to make a demo (course project)
- First chance: Monday, May 13, 2019
  - There will be about 3 exams per year

Study Material

- Lecture slides, related articles, and MATLAB examples will be distributed through MyCourses.
Return the Questionnaire

Confidence ranking
Demo Topic: Headphone Equalization

• Use a dummy head to measure the frequency response of a pair of headphones and improve the sound with digital filters.
• Date of presentation: 1.2.2019 (L3 Filter design)
• Supervisor: Juho Liski

Demo Topic: Graphic EQ

• Recently, we’ve learned how to design accurate graphic EQs. Try and compare a few of them.
• Date of presentation: 1.2.2019 (L3 Filter design)
• Supervisor: Vesa
Demo Topic: Pitch Detection

- Implement a pitch detection algorithm and explore its creative uses.
- Date of presentation: **8.2.2019** (L4 Analysis)
- Supervisor: Vesa

Demo Topic: Loudness Normalization

- Automatically equalize the levels of songs in a music playlist.
- Date of presentation: **8.2.2019** (L4 Analysis)
- Supervisor: Vesa
Demo Topic: Beat-Aligning Looper

• Automatically make loops of audio signal that can keep the rhythm
• Date of presentation: 8.2.2019 (L4 Analysis)
• Supervisor: Benoit

Demo Topic: Low latency beat detection

• Time domain onset detection for drums for live scoring
• Date of presentation: 8.2.2019 (L4 Analysis)
• Supervisor: Benoit
Demo Topic: Virtual Analog Phaser

- Emulate the famous MXR 100 Phaser guitar pedal
- Date of presentation: **15.2.2019** (L5 Effects)
- Supervisor: Vesa

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Demo Topic: Pink Noise Generators

- Find different ways to produce pink noise from scratch. Try them and compare.
- Date of presentation: **15.2.2019** (L5 Effects)
- Supervisor: Vesa
Demo Topic: Osc Sync Algorithms

- Implement a digital emulation of the sync effect present in classic analog synthesizers
- Date of presentation: 15.2.2019 (L5 Effects)
- Supervisor: Vesa

http://www.soundonsound.com/sos/nov02/articles/synthsecrets1102.asp

Demo Topic: Modal Reverb

- Simulate room reverberation using the modal approach
- Date of presentation: 8.3.2019 (L7 Reverberation)
- Supervisor: Benoit
**Demo Topic: Accurate Reverb Design**

- Study and implement an artificial reverb with an accurate frequency-dependent reverberation time
- Date of presentation: **8.3.2019** (L7 Reverberation)
- Supervisor: Benoit

**Demo Topic: Velvet-Noise Reverberator**

- Use recirculating velvet-noise filters to build a reverberator.
- Date of presentation: **8.3.2019** (L7 Reverberation)
- Supervisor: Benoit
Demo Topic: Resizing rooms

- Time domain onset detection for drums for live scoring
- Date of presentation: **8.3.2019** (L7 Reverberation)
- Supervisor: Benoit

Demo Topic: Sound Texture Synthesis

- Extend the sampling synthesis technique for sounds like fire, rain, ocean waves, and wind.
- Date of presentation: **15.3.2019** (L8 Physical)
- Supervisor: Benoit
Demo Topic: Virtual Wind Chime

- Simulating wind chime using modal synthesis
- Date of presentation: **15.3.2019** (L8 Physical)
- Supervisor: Benoit

Demo Topic: Polygonal Oscillator

- Implement a novel digital oscillator, which produces polygonal waveforms. Aliasing must be suppressed as well.
- Date of presentation: **15.3.2019** (L8 Physical)
- Supervisor: Vesa
Demo Topic: Infinite Sounds

- Expand a sound indefinitely! Use convolution with a special signal called “velvet noise” or a new FFT technique
- Date of presentation: 22.3.2019 (L9 Sampling rate conversion)
- Supervisor: Vesa

Demo Topic: What’s Wrong With MP3?

- Why do some people hate MP3? Time to reveal the artifacts introduced by lossy compression. Do it with a filter!
- Date of presentation: 29.3.2019 (L10 Audio coding)
- Supervisor: Vesa
## Demo Topic: Loudness Control

- Implement a digital loudness control function and experiment with it.
- Date of presentation: **29.3.2019** (L10 Audio coding)
- Supervisor: Vesa

![Loudness Control Image](http://productionadvice.co.uk/loudness-war-secret/)

## Demo Topics and Dates – Spring 2019

<table>
<thead>
<tr>
<th>Topic</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>L3 Headphone Equalization (Juho)</td>
<td>x</td>
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<tr>
<td>L3 Graphic EQ (Vesa)</td>
<td>x</td>
</tr>
<tr>
<td>L4 Pitch Detection (Vesa)</td>
<td>x</td>
</tr>
<tr>
<td>L4 Loudness Normalization (Vesa)</td>
<td>x</td>
</tr>
<tr>
<td>L4 Low latency beat detection (Benoit)</td>
<td>8.2.2019</td>
</tr>
<tr>
<td>L5 Beat-Aligning Looper (Benoit)</td>
<td>x</td>
</tr>
<tr>
<td>L5 Virtual Analog Phaser (Vesa)</td>
<td>15.2.2019</td>
</tr>
<tr>
<td>L5 Pink Noise Generators (Vesa)</td>
<td>x</td>
</tr>
<tr>
<td>L5 Osc Sync Algorithms (Vesa)</td>
<td>15.2.2019</td>
</tr>
<tr>
<td>L6 Modal Reverb (Benoit)</td>
<td>x</td>
</tr>
<tr>
<td>L6 Accurate Reverb Design (Benoit)</td>
<td>8.3.2019</td>
</tr>
<tr>
<td>L7 Velvet-Noise Reverberator (Benoit)</td>
<td>8.3.2019</td>
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<td>L7 Resizing rooms (Benoit)</td>
<td>8.3.2019</td>
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<td>L8 Sound Texture Synthesis (Benoit)</td>
<td>15.3.2019</td>
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<td>L8 Virtual Wind Chime (Benoit)</td>
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<td>L8 Polygonal Oscillator (Vesa)</td>
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<td>L9 Infinite Sounds (Vesa)</td>
<td>x</td>
</tr>
<tr>
<td>L10 What’s Wrong With MP3? (Vesa)</td>
<td>29.3.2019</td>
</tr>
<tr>
<td>L10 Loudness Control (Vesa)</td>
<td>29.3.2019</td>
</tr>
</tbody>
</table>

- x = taken
Demo Topics – Summary

V. Välimäki & B. Alary

• 4 weeks before the demo: Contact your supervisor (Benoit/Juho/Vesa)
• Meet with the supervisor to plan the demo
• Start working on your demo
  – Study literature to know what to do
  – Write MATLAB code and select/generate sounds and figures
  – Prepare a slide show (max 15 min and ~10 slides)
• A few days before your demo: meet your supervisor again to check audio demos and slides
• Test the demo at latest one day before presentation with Benoit
• Present your demo as a part of a lecture!
• Return the assignment (document of ~10 pages + code) 4 weeks after the demo at the latest
• You will get max 30 points from your finalized course project (demo)

Schedule for Demos

V. Välimäki & B. Alary

11 January 2019
45
What is a Good Demo?

- Directly to the point
  - No long history…
- Present logically
  - The problem
  - Signal processing solution(s)
  - Try to simplify (not just math equations)
  - Visualization: MATLAB figures, animations, … (font size, label axis)
  - Sound examples!!!
- Sound examples with clear differences
  - Clearly explain what to listen to (e.g. original vs. processed sound)
  - Must be heard in the noisy and reverberant lecture hall
- A good demo can be useful for teaching later!

Homework #1

- Plan your use of time with a concrete schedule
  - Take into account other courses/possible assignments and their deadlines, for example
- 5 credits = 26.7 h X 5 = 133.5 h of work
  - Lectures take 3 h X 10 = 30 h
  - Please plan 133.5 h – 30 h = 103.5 h of work on your own time
- DL: Thursday 17.01.2019 at 16.00
  - Return via MyCourses, please