Aalto University
School of Electrical
Engineering

Communication acoustics
Practicalities

Ville Pulkki

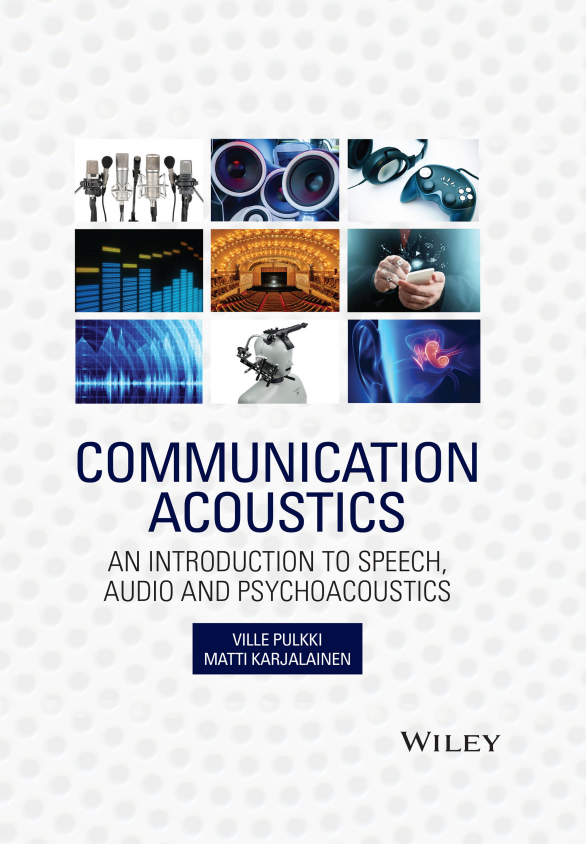
Department of Signal Processing and Acoustics
Aalto University, Finland

September 20, 2017

ELEC-E5600 Communication acoustics

- Lecturer: Prof. Ville Pulkki, email: Ville.Pulkki@aalto.fi
- Guest lecturers: postdoc Catarina Mendonca (Aalto), Teemu Koski (Cochlear Nordic)
- Assistant: Juhani Paasonen
- Lectures: 12.9.2017 – 19.10.2017
- Tuesdays U3 and thursdays U8 9:15 – 11:45
- Course information: MyCourses

Book for the course

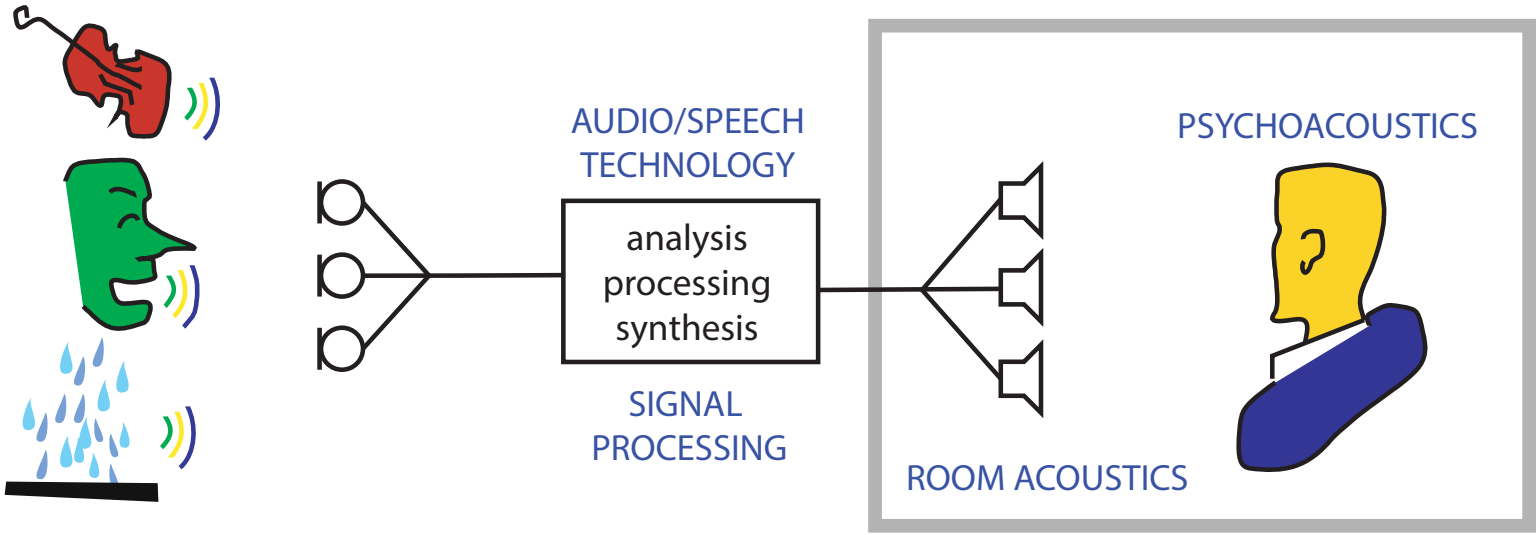


- Wider and translated version of Matti Karjalainen's "Kommunikaatioakustiikka"
  - Link to ebrary book with Aalto account
- E-books and hardcovers available in the Internet
- ELEC library has about 8 books to borrow
- Paper copy available
- 19 chapters, 456 pages, 250 figures

Chapters in the book

- Introduction
- Physics of sound
- Digital signal processing
- Electroacoustics
- Human voice
- Music instruments
- Anatomy and physiology of hearing
- Psychoacoustic testing
- Basic function of hearing
- Basic psychoacoustic quantities
- Further analysis in hearing
- Spatial hearing
- Auditory modelling
- Sound reproduction
- Time-frequency processing of audio
- Speech technologies
- Sound quality
- Other applications
- Technical audiology

Overall view



Major in Acoustics and Audio technology

Compulsory (30 credits)

ELEC-E5600	Communication Acoustics	5
ELEC-E5610	Acoustics and the Physics of Sound	5
SCI-E2430	Acoustical Measurements	5
ELEC-E5620	Audio Signal Processing	5
SCI-E2420	Virtual Acoustics	5
ELEC-E5630	Acoustics and Audio Technology Seminar (varying content)	5

Some optional courses (10-35 credits)

ELEC-E5650	Electroacoustics	5
ELEC-E5640	Noise control	5
ELEC-E5660	Special assignment in Acoustics and Audio Technology	1-10
ELEC-E5410	Signal Processing for Communications	5
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Completing the course

- Home work
  - Basic computation of reverb time, SPL etc.
  - pass/fail (mandatory to pass the course)
- Group work
  - Task is to research the perception of certain psychoacoustic quantity (sharpness, roughness etc)
  - pass/fail (+ 1 point to exam of successful workshop presentation)
- Examination
  - IF you have passed group work
    - Define 12 given concepts
    - Write TWO essays out of THREE given topics
  - IF you have NOT passed group work
    - Define 12 given concepts
    - Write THREE essays out of THREE given topics

Home work

- Estimate reverberation time and reverberation radius of a room you have access to using theoretical formulas
- Measure reverberation time and reverberation radius of the same room
- An exercise to estimate sound pressure level in case of multiple sound sources

Has to be passed to complete the course!

Group work

- The task (given 19.9) is to research the perception of certain psychoacoustic quantity (sharpness, roughness, etc)
- Groups of a few students
- Collect ten few-second sounds from your surroundings
- Run a multiple-stimulus psychoacoustic test with given web-based software ▸ Link to existing test
- Take the test yourself, and take the test of other students
- Plot the data
- Take the listening test of other students as well
- Analyze the sounds themselves using a simple auditory model
- Pass/fail grade is informed in modeling clinic 19.10
- Workshop 26.10, successful presentation: +1 points

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Not mandatory, but makes your life easier in the examination

Examination

Q1 Explain 12 concepts (9 points)

Q2 Essay 1

Q3 Essay 2

Q4 Essay 3

Answer to Q1, AND

- if you have passed group work: TWO essays (6 points each)

  OR

- if you have NOT passed group work: THREE essays (4 points each)

Examination

List of concepts that can be asked in question 1:
A-weighted sound level, Absolute threshold, Acoustic horizon, ADSR-sequence, Allophone, Approximant, Auditory event, Auditory nerve, Auditory stream, Bark, Binaural cues, Cepstrum, Cochlear amplifier, Cochlear implant, Concatenation cost, Critical band, Dichotic, Diotic, Equal loudness curves, ERB, Fricative, Gammatone filter bank, Glottis, Hearing level, Hearing threshold, Idiophone, Just intonation, Linear predictive coding, Loudness, Median plane, Method of adjustment, Modulation transfer function, Music information retrieval, Nasal tract, Ossicles, Otoacoustic emission, Outer hair cell, PEAQ, Phoneme, Pitch, Pink noise, Prosody, Roughness, Sound event, Source–filter model, Spot microphone, STIPA, Summing localization, Timbre, Travelling wave, Vacil, Voiced sound.

Total 12 concepts will be asked resulting in max 9 points

Examination

List of questions for Q2, Q3 and Q4.

- Make a schematic drawing of human speech production organs. Basic classes of phonemes, and their production and acoustic properties. Sketch the magnitude spectrum of a vowel, and explain using it the concepts of fundamental frequency and formant.
- Sensory consonance and dissonance. Intervals, musical scales and tuning systems. How the spectrum of musical instrument affects sensory consonance, when an interval is formed by playing two notes with same instrument? Discuss the relative levels of harmonics in this context. Some instruments do not have harmonic structure in their spectra. How does this affect consonance and dissonance of intervals?
- Modulation transfer function and STI in estimation of speech intelligibility. Sketch speech intelligibility [%] as function of STI for digits, short sentences, and logatomes.
- Explain the roles of inner and outer hair cells. Active function of cochlea. Sketch the velocity of the basilar membrane recorded at a single point when excited with sinusoids of different frequencies and levels, and explain them with functioning of the cells.
- Hearing impairments. Hearing threshold shift and recruitment. Stages of hair cell damage and the corresponding effect on neural tuning curves.
- Roughness, fluctuation strength and sharpness. Definitions, units and modeling
- Definitions and measurement of HRIR and HRTF. Sketch a typical HRIR and HRTF magnitude response. Which properties of HRIRs and HRTFs compose directional cues?
- Text-to-speech synthesis. Explain the basic principles of knowledge-based, unit-selection, and statistical parametric synthesis methods. Discuss the pros and cons of the methods.
- Amplitude panning and time delay panning. Definitions and common use. How do the gain difference and time delay transfer to directional cues? Which stereophonic microphone techniques are related to these techniques, and why?
- Perceptual measures and models for monaural audio quality. How are perceptual models utilised in estimation of degradation of sound quality? Which processing blocks are utilised in PAQM, and how PEAQ is different from it?

Tentative schedule

12.9 CH 2. *Homework given*
14.9 CH 7,8. (Catarina Mendonca, Aalto)
19.9 CH 9,10. **Homework deadline**
21.9 CH 11. *Assignment of topics, division to groups*
26.9 CH 12.
28.9 CH 13. **Delivery of sound files**
3.10 CH 14. *Listening tests start*
5.10 CH 5, 16. **Listening tests deadline**
10.10 CH 6,17. *Auditory modeling start*
12.10 CH 18 reserve. **Test result boxplots deadline**
17.10 CH 19. (Teemu Koski, Cochlear Nordic)
19.10 **Modeling clinic**. (Juhani Paasonen) (Group work pass/fail)
24.10 Examination.
26.10 Workshop. (Ville + Juhani)