Return to Main

Objectives

Transduction:
Sound Pressure Level
Physiology of the Ear

Perception:
Psychoacoustics
Equal Loudness
Bark and Mel Scales
Comparison

On-Line Resources:
Signal Modeling
Bilinear Transform
Auditory Web
Auditory.Org

LECTURE 04: HEARING PHYSIOLOGY

- Objectives:
  - Basic physiology
  - Frequency response implications
  - Nonlinear frequency warping
  - Bark and Mel scales

Note that this lecture is primarily based on material from the course textbook:

> X. Huang, A. Acero, and H.W. Hon, *Spoken Language Processing - A Guide to Theory, Algorithm, and System Development*, Prentice Hall, Upper Saddle River, New Jersey, USA, ISBN: 0-13-022616-5, 2001.

In addition, information from:

> D. O'Shaughnessy, *Speech Communications: Human and Machine,* IEEE Press, ISBN: 0-7803-3449-3, 2000.

has been used for the first slide.

Return to Main

Introduction:

01: Organization
(html, pdf)

Speech Signals:

02: Production
(html, pdf)

03: Digital Models
(html, pdf)

04: Perception
(html, pdf)

05: Masking
(html, pdf)

06: Phonetics and Phonology
(html, pdf)

07: Syntax and Semantics
(html, pdf)

Signal Processing:

08: Sampling
(html, pdf)

09: Resampling
(html, pdf)

10: Acoustic Transducers
(html, pdf)

11: Temporal Analysis
(html, pdf)

12: Frequency Domain Analysis
(html, pdf)

13: Cepstral Analysis
(html, pdf)

14: **Exam No. 1**
(html, pdf)

15: Linear Prediction
(html, pdf)

16: LP-Based Representations
(html, pdf)

Parameterization:

17: Differentiation
(html, pdf)

18: Principal Components
(html, pdf)

ECE 8463: FUNDAMENTALS OF SPEECH RECOGNITION

Professor Joseph Picone
Department of Electrical and Computer Engineering
Mississippi State University

email: picone@isip.msstate.edu
phone/fax: 601-325-3149; office: 413 Simrall
URL: http://www.isip.msstate.edu/resources/courses/ece_8463

Modern speech understanding systems merge interdisciplinary technologies from Signal Processing, Pattern Recognition, Natural Language, and Linguistics into a unified statistical framework. These systems, which have applications in a wide range of signal processing problems, represent a revolution in Digital Signal Processing (DSP). Once a field dominated by vector-oriented processors and linear algebra-based mathematics, the current generation of DSP-based systems rely on sophisticated statistical models implemented using a complex software paradigm. Such systems are now capable of understanding continuous speech input for vocabularies of hundreds of thousands of words in operational environments.

In this course, we will explore the core components of modern statistically-based speech recognition systems. We will view speech recognition problem in terms of three tasks: signal modeling, network searching, and language understanding. We will conclude our discussion with an overview of state-of-the-art systems, and a review of available resources to support further research and technology development.

Tar files containing a compilation of all the notes are available. However, these files are large and will require a substantial amount of time to download. A tar file of the html version of the notes is available here. These were generated using wget:

```
wget -np -k -m http://www.isip.msstate.edu/publications/courses/ece_8463/lectures/current
```

A pdf file containing the entire set of lecture notes is available here. These were generated using Adobe Acrobat.

Questions or comments about the material presented here can be directed to help@isip.msstate.edu.

19: Linear Discriminant Analysis
(html, pdf)

LECTURE 04: HEARING PHYSIOLOGY

- Objectives:
  - Basic physiology
  - Frequency response implications
  - Nonlinear frequency warping
  - Bark and Mel scales

Note that this lecture is primarily based on material from the course textbook:

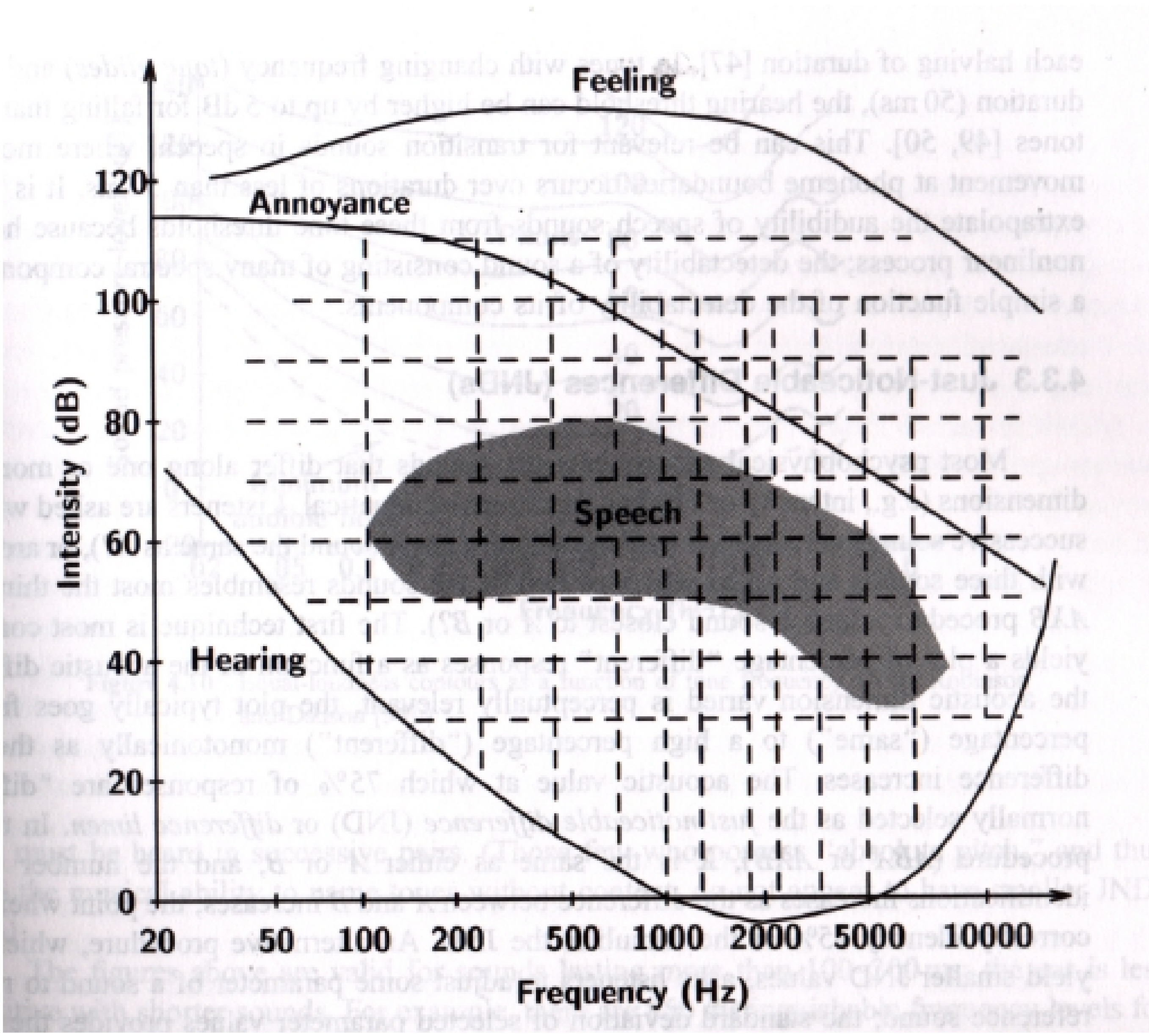
> X. Huang, A. Acero, and H.W. Hon, *Spoken Language Processing - A Guide to Theory, Algorithm, and System Development*, Prentice Hall, Upper Saddle River, New Jersey, USA, ISBN: 0-13-022616-5, 2001.

In addition, information from:

> D. O'Shaughnessy, *Speech Communications: Human and Machine*, IEEE Press, ISBN: 0-7803-3449-3, 2000.

has been used for the first slide.

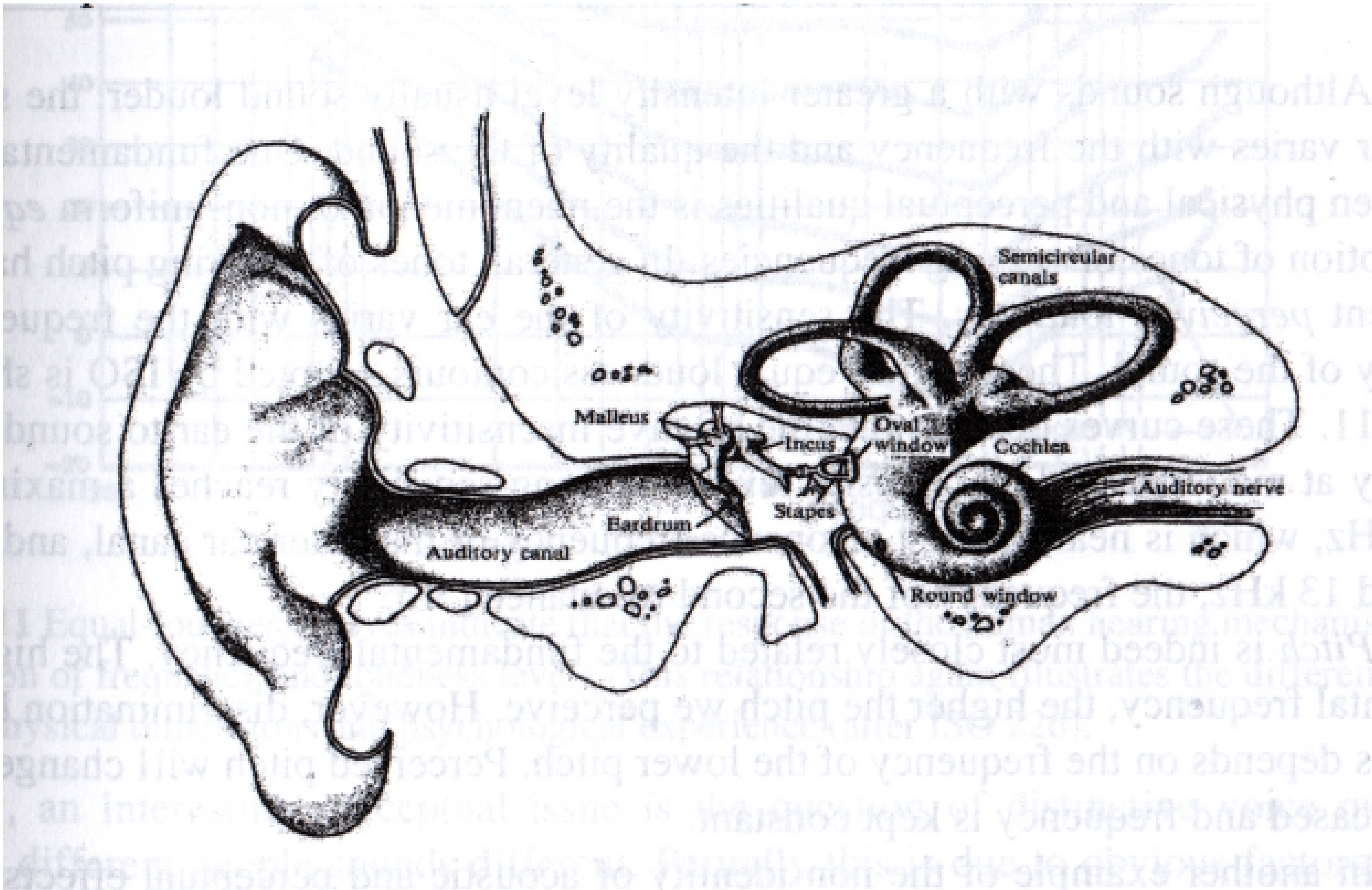
SOUND PRESSURE LEVEL



Key points:

- The ear is the most sensitive human organ. Vibrations on the order of angstroms are used to transduce sound. It has the largest dynamic range (~140 dB) of any organ in the human body.
- The lower portion of the curve is an audiogram - hearing sensitivity. It can vary up to 20 dB across listeners.
- Above 120 dB corresponds to your favorite heavy metal rock and roll band (or standing under a Boeing 747 when it takes off).
- Typical ambient office noise is about 55 dB.
- Three common weighting scales exist for intensity - A (SPL in the range 20 to 55 dB), B (SPL in the range 55 to 85 dB), and C (85 dB or more). A weighting is used most often in speech research (and by the government when setting regulations).

PHYSIOLOGY OF THE EAR



Key points:

- Three main sections: outer, middle, and inner. The outer and middle ears reproduce the analog signal (impedance matching); the inner ear transduces the pressure wave into an electrical signal.
- The outer ear consists of the external visible part and the auditory canal. The tube is about 2.5 cm long.
- The middle ear consists of the eardrum and three bones (malleus, incus, and stapes). It converts the sound pressure wave to displacement of the oval window (entrance to the inner ear).
- The inner ear primarily consists of a fluid-filled tube (cochlea) which contains the basilar membrane. Fluid movement along the basilar membrane displaces hair cells, which generate electrical signals.
- There are a discrete number of hair cells (30,000). Each hair cell is tuned to a different frequency.
- Place vs. Temporal Theory: firings of hair cells are processed by two types of neurons (onset chopper units for temporal features and transient chopper units for spectral features).
- Most mammals have similar hearing systems (cats and chinchillas are popular animals for experimentation).

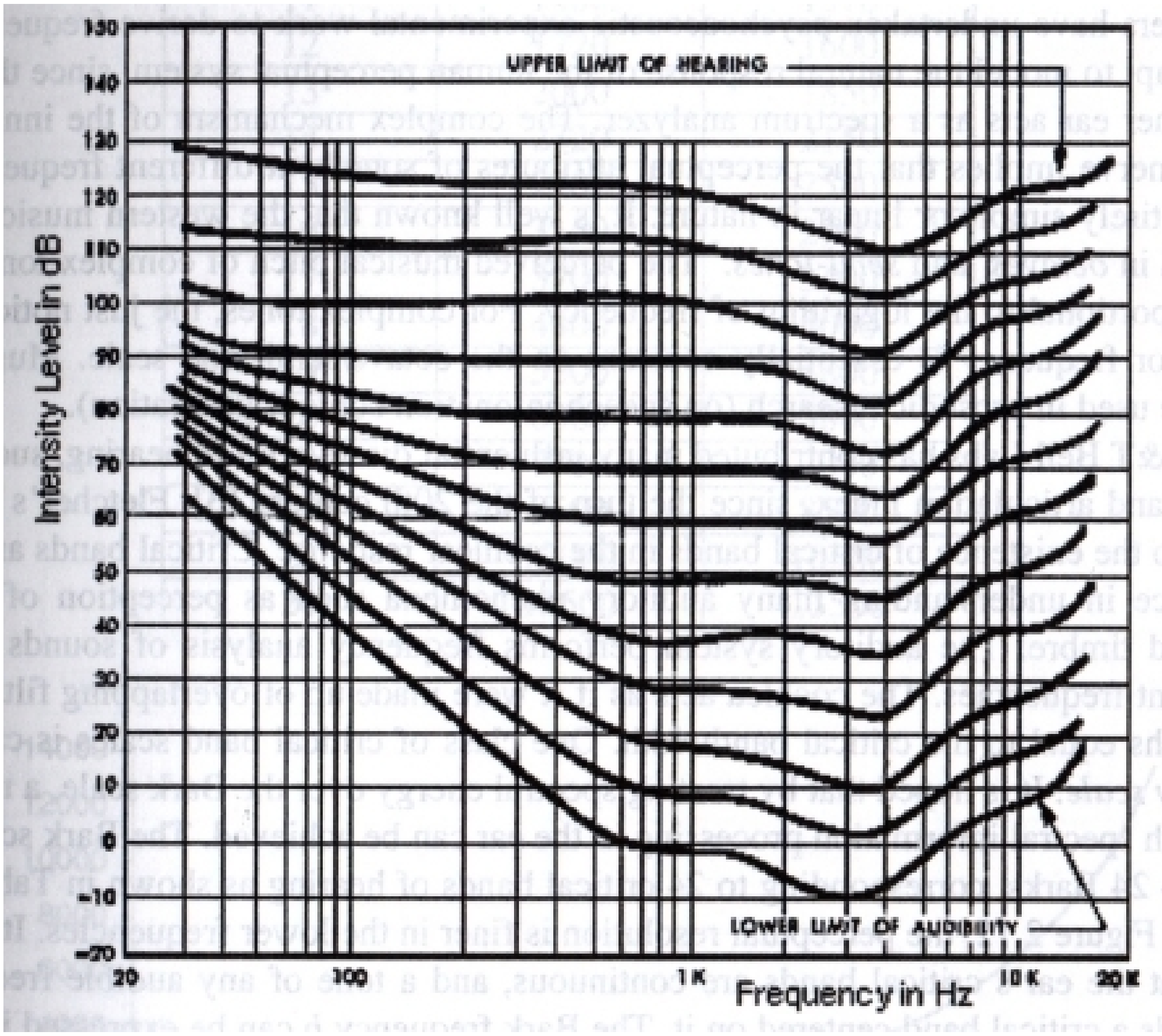
PHYSICAL VS. PERCEPTUAL ATTRIBUTES

- Psychoacoustics: a branch of science dealing with hearing, the sensations produced by sounds.
- A basic distinction must be made between the perceptual attributes of a sound and measurable physical quantities:

Physical Quantity	Perceptual Quality
Intensity	Loudness
Fundamental Frequency	Pitch
Spectral Shape	Timbre
Onset/Offset Time	Timing
Phase Difference (Binaural Hearing)	Location

- Many physical quantities are perceived on a logarithmic scale (e.g. loudness). Our perception is often a nonlinear function of the absolute value of the physical quantity being measured (e.g. equal loudness).
- Timbre can be used to describe why musical instruments sound different.
- What factors contribute to speaker identity?

EQUAL LOUNDESS CURVES



- **Just Noticeable Difference (JND)**: The acoustic value at which 75% of responses judge stimuli to be difference (also known as a difference limen).
- The perceptual loudness of a sound is specified via its relative intensity above the threshold. A sound's loudness is often defined in terms of how intense a reference 1 kHz tone must be heard to sound as loud.

NONLINEAR FREQUENCY WARPING: BARK AND MEL SCALES

- **Critical Bandwidths**: correspond to approximately 1.5 mm spacings along the basilar membrane, suggesting a set of 24 bandpass filters.

- **Critical Band**: can be related to a bandpass filter whose frequency response corresponds to the tuning curves of an auditory neurons. A frequency range over which two sounds will sound like they are fusing into one.

- **Bark Scale**:

$$Bark = 13\,\mathrm{atan}\left(\frac{0.76f}{1000}\right) + 3.5\,\mathrm{atan}\left(\frac{f^2}{(7500)^2}\right)$$

- **Mel Scale**:

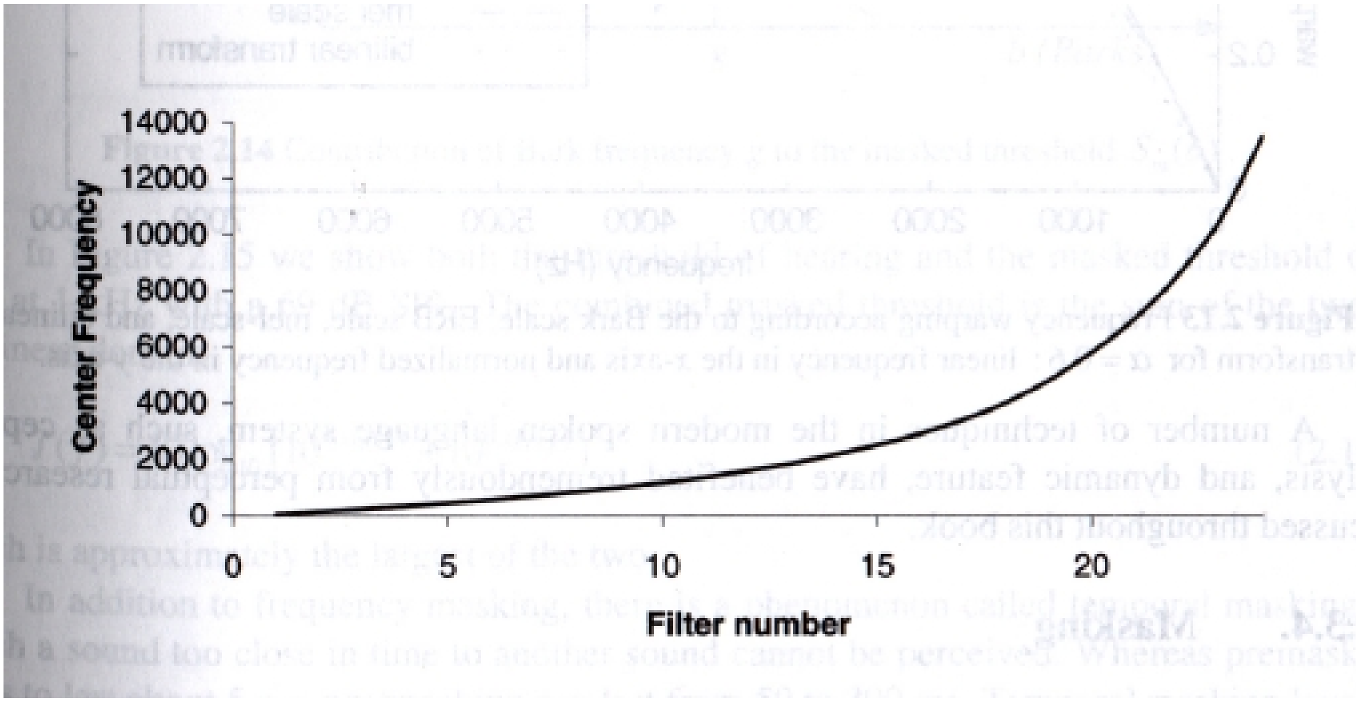
$$mel\ frequency = 2595\ \log10\ (1 + f/700.0)$$

- **Comparison**: filter bank implementations for a typical speech recognizer.

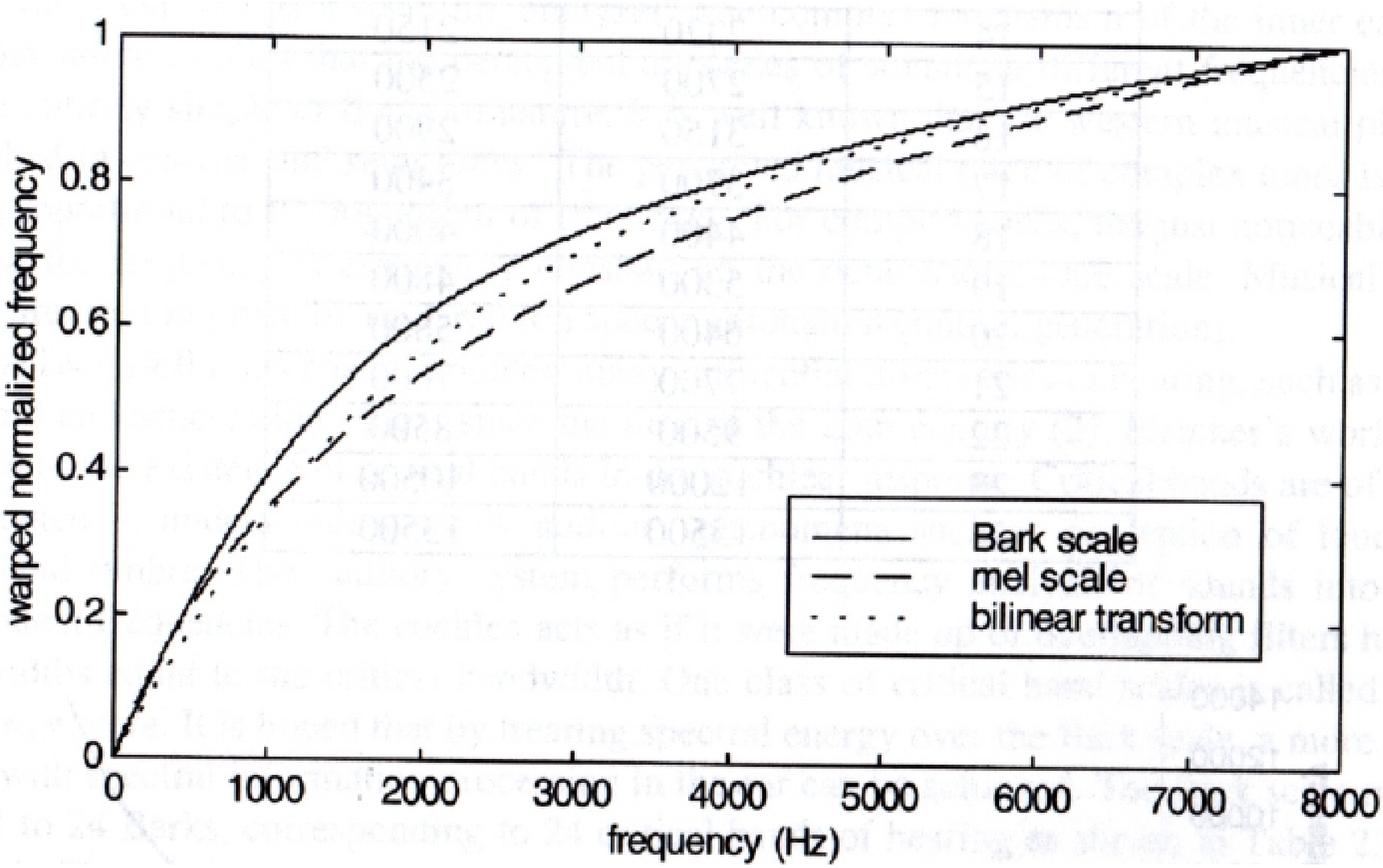
Index	Bark Scale		Mel Scale	
	Center Freq. (Hz)	BW (Hz)	Center Freq. (Hz)	BW (Hz)
1	50	100	100	100
2	150	100	200	100
3	250	100	300	100
4	350	100	400	100
5	450	110	500	100
6	570	120	600	100
7	700	140	700	100
8	840	150	800	100
9	1000	160	900	100
10	1170	190	1000	124
11	1370	210	1149	160
12	1600	240	1320	184
13	1850	280	1516	211
14	2150	320	1741	242
15	2500	380	2000	278
16	2900	450	2297	320
17	3400	550	2639	367
18	4000	700	3031	422
19	4800	900	3482	484
20	5800	1100	4000	556
21	7000	1300	4595	639
22	8500	1800	5278	734
23	10500	2500	6063	843
24	13500	3500	6964	969

24	13500	3500	6964	969

- **Nonlinear Frequency Warping**: The Bark scale implies a nonlinear frequency mapping of frequency.



A COMPARISON OF FREQUENCY WARPING FUNCTIONS



- Follow this link for more information on the bilinear transform.

Index of /publications/journals/ieee_proceedings/1993/signal_modeling

Name	Last modified	Size	Description
Parent Directory	01-Jan-1999 12:07	-	
paper_v2.pdf	22-Jun-1999 16:14	452k	

Return to Main

Overview:
Analog

Derivates:
Difference
Mapping

Impulse Invariance:
Mapping
Properties

Bilinear:
Equation
Properties

Applets:
Design

DESIGN OF IIR FILTERS FROM ANALOG FILTERS

We would like to leverage a large existing body of analog filter design theory (keeps those old analog people employed!). An analog filter may be described in three different ways:

(1) By its system function:

$$H_a(s) = \frac{B(s)}{A(s)} = \frac{\sum_{k=0}^{M} \beta_k s^k}{\sum_{k=0}^{N} \alpha_k s^k}$$

where $\{\alpha_k\}$ and $\{\beta_k\}$ are the filter coefficients.

(2) By a Laplace transform of the impulse response:

$$H_a(s) = \int_{-\infty}^{\infty} h(t) e^{-st} dt$$

(3) By a linear constant-coefficient differential equation:

$$\sum_{k=0}^{N} \alpha_k \frac{d^k}{dt^k} y(t) = \sum_{k=0}^{M} \beta_k \frac{d^k}{dt^k} x(t)$$

Each characterization results in a different digital filter.

Our conversion technique should have the following properties:

1. The $j\Omega$ axis in the s-plane should map onto the unit circle (so that the frequency response is preserved).

2. The left-half plane (LHP) of the s-plane should map into the inside of the unit circle in the z-plane (so that stability is preserved).

Auditory related WWW site index

Auditory/Hearing related Labs. in Japan

- ATR-HIP
  - Auditory Analysis and Speech Communications Group (tohkura@hip.atr.co.jp)
- Doshisha Univ.
  - Riquimaraux Lab. (Neurophysiology) (hrikimar@mail.doshisha.ac.jp)
- Electrotechnical Lab.
  - Acoustic Section (sato@etl.go.jp)
- Hitachi Advanced Research Lab.
  - Fukunishi Lab. (Computational Neuroscience) (fukunisi@harl.hitachi.co.jp)
- Hokkaido Univ.
  - Ifukube Lab. (Research Institute for Electronic Science) (ifukube@sense.hokudai.ac.jp)
- Japan Advanced Institute of Science and Technology (JAIST)
  - Akagi Lab. (akagi@jaist.ac.jp)
- Kanazawa Univ.
  - Kudo Lab. (School of Medicine) (kudo@med.kanazawa-u.ac.jp)
- Kumamoto Univ.
  - Ebata & Usagawa Lab. (Dept. of Erect. Eng. Comp. Sci.) (ebata@eecs.kumamoto-u.ac.jp, tuie@srv101.eecs.kumamoto-u.ac.jp)
- Kyushu Institute of Design
  - Fukudome Lab. (Dept. of Acoustic Design)
  - Iwamiya Lab. (Dept. of Acoustic Design) (iwamiya@kyushu-id.ac.jp)
  - Nakazima Lab. (Dept. of Acoustic Design)
  - Tsumura Lab. (Dept. of Acoustic Design)
- Matsushita Electric Industrial Co. Ltd. , Central Research Lab.
  - Health Electronics
- NHK Science and Technical Research Labs.
  - Auditory Science & Acoustics Research Devision (miyasaka@strl.nhk.or.jp)
- NTT Basic Research Labs.
  - Hearing Science Research Group (hirahara@idea.brl.ntt.co.jp)
  - Honda Research Group (hon@idea.brl.ntt.co.jp)
  - Imada Research Group (imada@nuesun.brl.ntt.co.jp)
  - Media Information Recognition Research Group (okuno@nue.org)
  - Sound Representation And Computer Music Research Group (osaka@idea.brl.ntt.co.jp)
- Nagoya Institute of Technology
  - Iwata Lab. (Dept of Electrical & Computer Engineering) (iwata@elcom.nitech.ac.jp)
- Nagoya Univ.
  - Itakura Lab. (Dept. of Information Electronics) (kaji@itakura.nuee.nagoya-u.ac.jp)

- Kakehi Lab. (Unit of Cognitive Informatics) (kakehi@info.human.nagoya-u.ac.jp)

- Nihon Univ.
  - Hideki Iwasawa (Dept. Psychology) (iwasawa@chs.nihon-u.ac.jp)
- Tohoku Univ.
  - Sone Lab. (Research Institute of Electrical Communication) (yoh@riec.tohoku.ac.jp, ken@sone.riec.tohoku.ac.jp)
  - Takasaka Lab. (Dept. of Otorhinolaryngology, School of Medicine) (takasaka@orl.med.tohoku.ac.jp)
  - Wada Lab. (Dept. of Mechanical Engineering)
- Tokyo Medical and Dental Univ.
  - Taniguchi Lab. (Dept. of Neurophysiology, Medical Research Institute) (horinphy@tmd.ac.jp)
- Tokyo Univ. of Agriculture & Technology
  - Atoda Lab. (Graduate School of Bio-Applications and Systems Engineering) (atoda@cc.tuat.ac.jp)
- AURIS
  - Auditory Mailing List in Japan (tsuzaki@hip.atr.co.jp)

Auditory/Hearing Labs. in North America

- Arizona State Univ.
  - Neural Computation Lab
- AT&T Research
  - Jont B. Allen's Home Page
- Boston Univ.
  - Dept. of Biomedical Engineering
- Boys Town National Research Hospital
  - Cochlear Mechanics
  - Neurobiological Studies of Hearing
- California Institute of Technology
  - Birdsong Index
  - Computation Neural Systems (CNS)
    - Carver Mead's group (Physics of Computation)
  - Konishi-Lab, (Division of Biology)
- Carleton Univ.
  - The Neurosciences at Carleton Univ.
- Central Institute for the Deaf (CID)
  - Speech and Hearing Dept.
- Indiana Univ.
  - Speech Research Lab. (Prof.Pisoni)
- Interval Research Corporation
  - Malcolm Slaney home page
- Johns Hopkins Univ.
  - Research and Training Center for Hearing and Balance

- Loyola Univ.
  - Parmly Hearing Institute
- Lucent Technologies
  - Bell Labs
- Massachusetts Institute of Technology (MIT)
  - Auditory home page (by Dan Ellis) (Media Lab.)
  - Auditory Physiology Group (RLE)
  - Micromechanics Group (RLE)
  - Sensory Communication Group (RLE)
- McGill Univ.
  - Auditory Perception (by Norma Welch)
  - Auditory Research Lab. (by Al Bregman)
- National Institutes of Health (NIH), NIDCD
  - Biophysics Section
- New York Univ.
  - Center for Neural Science
- Oregon Graduate Institute of science & technology (OGI)
  - Center for Spoken Language Understanding (CSLU)
- Queen's Univ.
  - Visual and Auditory Neuroscience Lab. (Dept. of Psychology)
- Research in the Hearing Sciences
- San Jose State Univ.
  - Richard O. Duda's home page (Dept. of Electrical Engineering)
- The Eaton Peabody Lab. of Auditory Physiology
- The Realization Group at ICSI
- The House Ear Institute
- The South Bank Univ. (U.K.)
  - CT of the Ear
- Univ. of California Santa Cruz (UCSC)
  - Perceptual Science Laboratory (PSL)
- Univ. of California at Berkelry (UCB)
  - International Computer Science Institute (ICSI)
  - Auditory Perception Lab.
- Univ. of Illinois
  - Automatic Speech Recognition Lab.
- Univ. of Merryland
  - Neural Systems Lab. (NSL) (S.Shamma's group)
- Univ. of Michigan
  - Kresge Hearing Research Institute Labs.
- Univ. of Minnesota
  - Cochlear Anatomy Lab.
- Univ. of Texas, Dallas
  - "The Best" List of Audiology Hyperlinks (by Paul Dybala)
- Univ. of Washington
  - Virginia Merrill Bloedel Hearing Research Center
- Univ. of Wisconsin at Madison (UWM)

- Auditory Behavioral Research Lab.
    - Center for Neuroscience, Auditory Systems
    - The Dept. of Neurophysiology
- Washington Univ.
    - Cochlear Fluids Research Lab.

Auditory/Hearing Labs. in Europe

- Cambridge, UK
    - MRC-APU
- Carl von Ossietzky-Universitat Oldenburg, Germany
    - Physics Dept., ACOUSTICS
- Institute for Perception Research (IPO), Netherland
    - Hearing and Speech
- Karolinska Institute, Stockholms, Sweden
    - Division of Physiology II (Det. of Physiology and Pharmacology)
- Keele Univ., UK
    - Communication and Neuroscience
- Kungl Tekniska Hogskolan (KTH), Sweden
    - Dept. of Speech, Music and Hearing
- Leicester Univ., UK
    - Bioengineering, Transducers & Signal Processing Research Group
- Ecole Polytechnique Federale de Lausanne
    - Andr van Schaik's Home Page (Neural Computation Group)
- Paris 7 Univ., France
    - Alain de Cheveign's Home page (UFRL-Linguistics Dept.)
- Ruhr University - Bochum, Germany
    - Institute fur Neuroinformatik
- Technical Univ. of Denmark
    - Dept. of Acoustic Technology
- Univ. of Bristol, UK
    - Bat Ecology and Bioacoustics Lab.
- Univ. College London, UK
    - Hearing and Speech Perception Research Group (HASP)
- Univ. of Darmstadt, Germany
    - The Darmstadt Auditory Research Group
- Univ. of Essex, UK
    - Hearing Research Lab.
- Univ. of Sussex, UK
    - Prof. C.Darwin's Home Page (School of Biological Sciences)

Auditory/Hearing Labs. in Oceania

- Victoria Univ. of Wellington, New Zealand
  - The Psychophysics lab, the psychophysics of human hearing

---

Neuroscience WWW site

- Harvard Univ., USA
  - The Harvard Brain
  - The Whole Brain Atlas
- Human Brain Project, USA
- Human Developmental Anatomy Center a collection of existing histological material., USA
- Neuroscience on the Internet, USA
- Neuroscience Web Search, USA
- Purkinje Park, the Bower lab WWW Home Page, USA
- The American Society of Mammalogists, USA
  - Mammal Slide Lib.
- The Sheep Brain Atlas, USA
- Univ. of Wisconsin Madison, USA
  - Comparative Mammalian Brain Collection
  - NeuroNews and Views (by Center for Neuroscience)
  - The Dept. of Neurophysiology

Speech WWW site

- AIST Nara, Japan.
  - Speech/Acoustic WWW site (by Prof. Shikano's Lab.)
- Austrian Academy of Sciences, Austria
  - Acoustics Research Lab.
- Central Institute for the Deaf (CID), USA
  - Speech and Communications Lab. (by James D. Miller)
- Haskins Labs., USA
- Institute for Perception Research (IPO), The Netherlands
  - Speech on the Web
- Ohio state Univ., USA
  - Robert Fox's Home Page
- UCL Psychology Speech Group, UK
- Univ. of Texas, UK
  - Diehl Lab Home Page (Speech Lab.)

- Univ. of Waterloo, Canada
    - Li Deng's Home Page

Academic Societies

- Association for Research in Otolaryngology (ARO), USA
- Deutsche Gesellschaft fur Akustik (DEGA) , German
- European Speech Communication Assoceation, France
- The Acoustical Society of America (ASA), USA
- The Acoustical Society of Japan (ASJ), Japan
- The Institute of Electronics, Information and Communication Engineers (IEICE), Japan

---

Hardware & Software links

- Bruel & Kjaer
- Linux Applications and Utilities Page
- LINUX Home Page
- The MathWorks, Inc. (MATLAB)
- Linux Square (in Japanese)
- Welcome to Linux World (in Japanese)

General Search site

- AccuFind
- AltaVista
- Excite Reviews
- HotBot
- Infoseek
- Library of Natural Sounds
- Lycos
- Metacrawler
- Open Text Web Index
- Speech and Language Web Resources
- WebCrawler
- Yahoo

- BEKKOAME (in Japanese)
- CSJ index (in Japanese)
- Goo (in Japanese)
- Japanese Yahoo (in Japanese)
- NTT URL Square (in Japanese)
- ODIN (in Japanese)
- Open Text Web Index (in Japanese)
- Senrigan search (in Japanese)

Index site

- Durham Univ., UK
- The ACOUSTICS page, UK
- Otology Online, USA
- Spatial Sound Index, USA
- The Collection of Computer Science Bibliographies, Germany
- Univ. of Darmstadt, Germany
  - DARG Index
- WWW Home Server Guide (JICST INDEX), Japan

Last update: NOV. 07, 1997 by Hitomi

AUDITORY list home page

Welcome to the web site of the AUDITORY list, which provides information about and related to the AUDITORY list, an email list for the discussion of organizational aspects of auditory perception. The list was created in 1992 by Professor Albert S Bregman of the McGill University Department of Psychology. It is currently maintained by Dan Ellis, who also runs this web site.

On this page: Notices - Joining AUDITORY - AUDITORY archives - Local information - Seminars - Journal contents - Source code - Other sites - Links to links

---

Notices

This section contains messages that I have decided to distribute through the web rather than sending to the AUDITORY list. I have refrained from posting them because of their size or tangential relevance. I hope this is an appropriate alternative.

- **2001-04-30:** This site has moved to a new address, www.auditory.org.

Joining the AUDITORY list

By joining the AUDITORY email list, you will receive all the postings via email, and you will be able to contribute to the discussions. You can join the list by filling in the form on the AUDITORY membership questionnaire.

Archives of postings to the AUDITORY list

Messages to the list since its creation in 1992.

Other local information pages

- Information on auditory demonstrations available as CDs

Seminars on hearing

There are numerous seminar series around the planet devoted to issues of audition relevant to this group. Here are collected some web links to the ones I know about. Please send me suggestions for additions.

- Archives of talk announcements for the Stanford Hearing Seminar, organized by Malcolm Slaney.
- The UC Berkeley Ear Club, hosted by the UCB Auditory Perception Lab.
- Current and recent talks at the Boston University Hearing Research Seminar series, hosted by the BU Hearing Research Center.
- The Auditory Physiology Seminar Series at the Eaton-Peabody Laboratories in Boston.

Journal Contents/Abstracts

I'm afraid I haven't been keeping all of these up to date, so coverage is partial at best. If anyone knows better sources for this data, please let me know.

- Indexes to some recent ASA meetings including all the abstracts since the 124th meeting (1992). (The ASA provide an excellent searchable index to the most recent meeting).
- The Acoustical Society also offers Tables of contents for JASA for 1995 (vol 97) onward.
- John Krantz's list of psychologically-related electronic journals and periodicals etc.

- The journal Music Perception has its own web site, including abstracts.

- The **Journal of New Music Research** has an Electronic Appendix containing abstracts for the journal issues, pictures and sound examples.

Source code & other pieces

- Malcolm Slaney had produced various code examples including his very useful Auditory Toolbox, including various signal transforms and representations.

- John Culling has made available PipeWave, his package of signal processing and auditory modelling modules that can be connected via Unix pipes.

- The excellent DSAM (formerly LUTEar) auditory modelling source code is available from its source, the Hearing Research Laboratory at the University of Essex (formerly at Loughborough).

- Roy Patterson's group at the MRC-APU in Cambridge, UK, has made available a version of their Auditory Image Model spanning the gammatone front-end to the strobed image output.

- Improved code for reading audio files in WAV and .AU format into MATLAB, with thanks to François Caron. (MEX source for reading the Audio Interchange File Format is here under the name of SoundMex4.1. Choose between Mac and Unix versions (compilable on SGI/DEC/Alpha/Sun)). (A version of this latter package for Matlab 5 and which handles a wide range of soundfile formats is available as SoundMex5 (for Unix)).

- TeX templates for JASA are here (contributed by by Krishna Govindarajan)

Other sites

- Jont Allen has set up a site, auditorymodels.org to host several discussion lists dealing with models of ear function and cochlear mechanics.

- The site of the Parmly Hearing Institute contains some interesting demonstrations and discussions.

- An interesting site of Auditory Perception: Tutorials and Experiments from Norma Welch. It includes quantitative tests of some classic phenomena that you can run through your web browser!

- The Acoustical Society of America has its own web site now, which includes introduction to the society and various other topics in acoustics. The ASA is a part of the American Institute of Physics, which also provides the PINET FTP site, including information on electronic abstract submission for Acoustical Society meetings.

- The Association for Research in Otolaryngology has an attractive and useful web site, including abstracts from their meetings and a member index.
- A beautifully-organized web presentation on the problem of sound localization research has been put together by Dick Duda, including as clear and succinct a definition of the problem of auditory scene analysis as you will find anywhere.
- Be entertained and edified by the polished SineWave Speech page at Haskin's lab - hear for yourself speech without traditional speech cues.

Pages of auditory/acoustics links

I'm afraid this is a meta-link-list. Rather than compiling my own comprehensive list of auditory-related sites, here are some pointers to other peoples. I wirry that this may be a degenerate activity - list of links to other people's lists of links, but I've tried to be selective for pages with some description and/or very wide coverage.

- The SOCRATES Thematic Network in Phonetics and Speech Communication has a project in Computer-Aided Learning, which has resulted in a well-edited Inventory of Internet Resources including useful annotated indexes of linguistic data, speech processing tools, etc.
- There is a very comprehensive index of WWW Information for Speech/Acoustics Research from the lab of Prof. Shikano at the Nara Institute of Science and Technology (NAIST).
- A list of auditory links from the Darmstadt Auditory Research Group in Germany. Includes a couple of lines describing the sites of each of about 50 research groups.
- Doug Nunn's list of Acoustics links at Durham - about 100 links including groups, journals and software.

Please send me your suggestions of other things to do on this page.

Updated: $Date: 2001/09/24 22:17:28 $
DAn Ellis <dpwe@ee.columbia.edu>
Department of Electrical Engineering
Columbia University in the City of New York