#### **Digital Speech Processing**

#### Professor Lawrence Rabiner UCSB Dept. of Electrical and Computer Engineering Jan-March 2013

## **Course Description**

This course covers the basic principles of digital speech processing:

- Review of digital signal processing
- MATLAB functionality for speech processing
- Fundamentals of speech production and perception
- Basic techniques for digital speech processing:
  - short time energy, magnitude, autocorrelation
  - short time Fourier analysis
  - homomorphic (convolutional) methods
  - · linear predictive methods

#### - Speech estimation methods

- speech/non-speech detection
- voiced/unvoiced/non-speech segmentation/classification
- pitch detection
- formant estimation

#### - Applications of speech signal processing

- Speech coding
- Speech synthesis
- Speech recognition/natural language processing

A MATLAB-based *term project* will be required for all students taking this course for credit.

#### **Course Information**

- **Textbook**: L. R. Rabiner and R. W. Schafer, Theory and Applications of Digital Speech Processing, Prentice-Hall Inc., 2011
- Grading:
  - Homework 20%
  - Term Project 20%
  - Mid Term Exam 20%
  - Final Exam 40%
- Prerequisites: Basic Digital Signal Processing, good knowledge of MATLAB
- *Time and Location*: Tuesday, Thursday, 10:00 am to 11:20 am, Phelps 1437.
- Course Website: www.ece.ucsb.edu/Faculty/Rabiner/ece259
- Office Hours: Tuesday, 1:00-3:00 pm







🥹 New Page 1 - Mozilla Firefox		
<u>File E</u> dit <u>V</u> iew Hi <u>s</u> tory <u>B</u> ookmarks	Iools Help	
< 🕑 · C × 🏠 🥯	http://www.ece.ucsb.edu/Faculty/Rabiner/ece259/	<b>A</b>
🔎 Most Visited 📄 Comcast 📋 Custom	ize Links 📄 Free AOL & Unlimited 🌔 Free Hotmail 📄 Member Services 📄 Online Schoolyard 📄 RealPlayer 📄 Snapshot Marquee 📄 Snapshot Window	>>
Google	🔄 🔧 Search 🛛 🖗 ኞ Sidewiki 🔹 🏠 Bookmarks • 💷 • 🖑 Check • 🏭 Translate • 🔦 AutoLink • 🎦 AutoFill • 🌽 🧔 • 🏦 🌗	**
🚱 New Page 1	*	-
UCSB University of California-Santa	Lecture 16: Speech Waveform CodingAdaptive and Differential Quantization: <u>(Lecture 16_fall_2010.pdf)</u> : 6-to-a-page: <u>(Lecture 16_fall_2010_6tp.pdf)</u> Lecture 17: Speech Coding MethodsModel-Based Approaches: <u>(Lecture 17_fall_2010.pdf)</u> : 6-to-a-page: <u>(Lecture 17_fall_2010_6tp.pdf)</u>	
Barbara	Homeworks:	•
<del>CP</del>	Problem Set 1: (ps1.pdf); PS1 solution: Problem Set 2: (ps2.pdf); PS2 solution: Problem Set 3: (ps3.pdf); PS3 solution: Problem Set 4: (ps4.pdf); PS4 solution: Problem Set 5: (ps5.pdf) : PS5 solution:	
Lawrence Rabiner Professor	Problem Set 6: ( <u>ps6.pdf</u> ); PS6 solution: Problem Set 7: ( <u>ps7.pdf</u> ); PS7 solution: Problem Set 8: ( <u>ps8.pdf</u> ); PS8 solution:	
Home Page	Speech Files	
<u>Speech Recognition</u> <u>Course</u>	test_16k.wav: (test_16k.wav) ah.wav: (ah.wav)	
Digital Speech Processing Course	should.wav: (should.wav) s1.wav: (s1.wav); pitch period contour for s1.wav: (pp1.mat) s2.wav: (s2.wav); pitch period contour for s2.wav: (pp2.mat)	
Publications List (Papers and Patents)	s3.wav: (s3.wav); pitch period contour for s3.wav: (pp3.mat) s4.wav: (s4.wav); pitch period contour for s4.wav: (pp4.mat) s5.wav: (s5.wav); pitch period contour for s5.wav: (pp5.mat)	
<u>Recent Talks</u>	s6.wav: (s6.wav); pitch period contour for s6.wav: (pp6.mat) we were: (we were away a year ago, Irr way)	
Personal Information	isolated digit training files: (digits_train.zip) isolated digit testing files: (digits_test.zip)	
AT&T Career Photos	isolated digit training files (raw-no endpoints marked): (digits_train_raw.zip) isolated digit testing files (raw-no endpoints marked): (digits_test_raw.zip)	
Suzanne Watercolors		
and Baskets	Matlab Files:	•
	loadwav.m: (loadwav.m)	-

Download homework assignments, speech files

7

Project Suggestions:       Calculate Using Sugestions:       Calculate Using Sugestions:       Calculate Using Sugestions:         Course Transaction       Test Suggestions:       Calculate Using Sugestions:       C	🔌 New Page 1 - Mozilla Firefox				
C       C	Eile Edit View History Bookmarks	Iools Help			
Most Nate:       Concurst:       Concurst:       The extense:       Online Schooled:       Reading:       Support:       Support	🕐 🖸 🗶 🙆 http://www.ece.ucsb.edu/Faculty/Rabiner/ece259/				
Cocycle       Image: Search + Image: Statewist + Image: The Address + Imag	🙍 Most Visited 🗋 Comcast 📋 Customize Links 📄 Free AOL & Unlimited 🌓 Free Hotmail 📄 Member Services 📄 Online Schoolyard 🇋 RealPlayer 📄 Snapshot Marquee 🇋 Snapshot Window 🛛 🔹				
New Page 1       Image: Second Sector Second Second Sector Second Second Sector Sector Second Sector S	Google	🔽 🔧 Search 📲 🖉 Sidewiki 🔹 🏠 Bookmarks * 💷 🔹 🌮 Check 🔹 🌆 Translate 🔹 🔨 AutoLink 🔹 📔 AutoFill 🔹 🅢 🧔 * 🎰 👘	»		
UCSB       test_f6k.wav)       ah.wav: (test_f6k.wav)         University of California-Santa Barbara       st.wav: (st.wav); pitch period contour for s1.wav: (pp1.mat)         St.wav: (s1.wav); pitch period contour for s1.wav: (pp2.mat)         Save: (s3.wav); pitch period contour for s3.wav: (pp2.mat)         Save: (s3.wav); pitch period contour for s3.wav: (pp2.mat)         Save: (s5.wav); pitch period contour for s3.wav: (pp3.mat)         Save: (s5.wav); pitch period contour for s5.wav: (pp5.mat)	🕞 New Page 1		-		
University of California-Santa Barbara       \$1.wav: (\$1.wav); pitch period contour for \$1.wav: (pp2.mat) \$2.wav: (\$2.wav); pitch period contour for \$3.wav: (pp2.mat) \$3.wav: (\$3.wav); pitch period contour for \$3.wav: (pp2.mat) \$3.wav: (\$4.wav); pitch period contour for \$3.wav: (pp2.mat) \$3.wav: (\$5.wav); pitch period contour for \$3.wav: (pp2.mat) \$3.wav: (\$5.wav); pitch period contour for \$3.wav: (pp2.mat) \$3.wav: (\$5.wav); pitch period contour for \$3.wav: (pp5.mat) \$5.wav: (\$5.wav); pitch period contour for \$5.wav: (pp6.mat) \$5.wav: (\$6.wav); pitch period contour for \$5.wav: (pp6.mat) \$5.wav: (\$0.adwav.m) \$5.wave: (\$0.wav: (\$0.adwav.m) \$2.wave: (\$0.wave:m: \$0.wave:m: \$	UCSB	test_16k.wav: (test_16k.wav) ah.wav: (ah.wav) should.wav: (should.wav)	1		
California-Santa         Barbara         Wax: (S2.way); pitch period contour for s2.wax: (pp2.mat)         Sawa: (S3.way); pitch period contour for s3.wav: (pp4.mat)         Sawa: (S3.way); pitch period contour for s3.wav: (pp5.mat)         Sawa: (S3.way); pitch period contour for s5.wav: (pp6.mat)         Sawa: (S3.way); pitch period contour for s5.wav: (pb6.mat)         Sawa: (S3.way); pitch period contour for s5.wav: (pb6.mat)         Sawa: (S3.way); pitch period contour for s5.wav: (pb7.mat)         Isolated digit testing files: (digits_train_raw.zip)         bigital Speech         Processing Course <t< th=""><th><u>University of</u></th><th>s1.wav: (s1.wav); pitch period contour for s1.wav: (pp1.mat)</th><th></th></t<>	<u>University of</u>	s1.wav: (s1.wav); pitch period contour for s1.wav: (pp1.mat)			
Barbara       s3.wav; (s3.wav; prich period contour for s3.wav; (pp3.mat)         s4.wav; (s4.wav; prich period contour for s5.wav; (pp5.mat)         s5.wav; (s5.wav;); pitch period contour for s5.wav; (pp5.mat)         s6.wav; (s6.wav;); pitch period contour for s5.wav; (pp6.mat)         we_were: (we were away ayear ago_fr.wav)         isolated digit sting files; (digits_test_p)         isolated digit sting files; (digits_test_raw.zip)         isolated might setwav.m;         course         Digital 5peech         Processing Course         Matlab Files:         Isodawav.m; (saveraw.m)         isodare.m; (saveraw.m)         isodare.m; (saveraw.m)         isodare.m; (saveraw.m)         isodare.m; (saveraw.m)         secent Talks         Personal Information         ATST Career Photos         Suzanne Watercolors and Baskets         S	California-Santa	s2.wav: (s2.wav); pitch period contour for s2.wav: (pp2.mat)	R		
st.wav: (st.wav); pitch period contuct for st.wav: (pp5.mat)         isolated digit testing files: (digits_train_zip)         isolated digit testing files: (digits_test_raw.vip)         isolated digit testing files: (av-no endpoints marked): (digits_test_raw.zip)         isolated digit testing files: (severav.m)         saverav.m: (savewav.m)         loadrav.m: (loadrav.m)         saverav.m: (saverav.m)         grayscale.m: (grayscale.m)         fxquant.m: (fxquant.m)         psectr: (spectry)         Recent Talks         Project Suggestions: (cholesky_full	Barbara	s3.wav: (s3.wav); pitch period contour for s3.wav: (pp3.mat)	F		
Source		s4.wav: (s4.wav), pitch period contour for s4.wav: (pp4.mat)			
wwwwwwwwwwwwwwwwwwwwwwwwwwwwwwwwwwww		s6.way (s6.way), pitch period contour for s6.way (pp6.mat)			
isolated digit training files: (digits_train.zip) isolated digit training files: (digits_train.zip) isolated digit training files: (digits_train_raw.zip) isolated digit training files: (digits_train_raw.zip) isolated digit training files (raw-no endpoints marked): (digits_test_raw.zip)         Lawrence Rabiner Professor       Matlab Files:         Home Page       Ioadwav.m: (loadwav.m) savewav.m: (savewav.m) loadraw.m: (loadraw.m) savewav.m: (savewav.m) processing Course Processing Course and Patents)       Ioadwav.m: (loadwav.m) savewav.m: (savewav.m) pspect.m: (grayscale.m) fxquant.m: (fxquant.m) pspect.m: (spectgr.m) LPC solutions: (cholesky_full.m), (durbin.m), (lattice.m)         Personal Information AT&T Career Photos Suzanne Watercolors and Baskets       General Project Suggestions: General Project Details: (LPC Vocoder Project.pdf) Project Schedule (UCSB-2009): User Interface Example (Sound Spectrograms): (GUI_plot_spectrogram_ucsb.m), (select_dir.m)         Oded: Material: (oded_material.zip)       Vertor		we_were: (we were away a year ago_irr.wav)			
Lawrence Rabiner Professor       isolated digit taining files (raw-no endpoints marked): (digits_train_raw.zip) isolated digit taining files (raw-no endpoints marked): (digits_test_raw.zip)         Lawrence Rabiner Professor       Matlab Files:         Base       Ioadwav.m: (loadwav.m) savewav.m: (savewav.m) obaraw.m: (savewav.m) savewav.m: (savewav.m) obaraw.m: (savewav.m) grayscale.m: (grayscale.m) fxquant.m: (fxquant.m) pspectm: (grayscale.m) fxquant.m: (staveraw.m) grayscale.m: (spectm) savefar.m)         Publications List (Papers and Patents)       pspectm: (spectm) spectgr.m) LPC solutions: (cholesky_full.m), (durbin.m), (lattice.m)         Project Suggestions:       General Project Suggestions: (Digital Speech Processing Projects.pdf) LPC Vocoder Project Details: (LPC Vocoder Project.pdf) Project Schedule (UCSB-2009): User Interface Example (Sound Spectrograms):(GUI_plot_spectrogram_ucsb.m), (select_dir.m)         Oded:Material: (oded_material.zip)       T		isolated digit training files: (digits_train.zip)	ł		
Lawrence Rabiner Professor       isolated digit training files (raw-no endpoints marked): (digits_test_raw.zip) isolated digit testing files (raw-no endpoints marked): (digits_test_raw.zip)         Home Page       Matlab Files:         Speech Recognition Course       Ioadwav.m: (loadwav.m) savewav.m: (saveraw.m) Ioadraw.m: (loadraw.m) savewav.m: (saveraw.m) grayscale.m: (grayscale.m) fxquantm: (saveraw.m) spect.m: (spectm) spect.m: (spectm) spect.m: (spectm) spectr.m: (spectm) LPC solutions: (cholesky_full.m), (durbin.m), (lattice.m)         Publications List (Papers and Patents)       Project Suggestions: General Project Suggestions: (Digital Speech Processing Projects.pdf) LPC vocoder Project Details: (LPC Vocoder Project.pdf) Project Schedule (UCSB-2009): User Interface Example (Sound Spectrograms): (GUL plot_spectrogram_ucsb.m), (select_dir.m)         Oded:Material: (oded_material.zip)       V		isolated digit testing files: (digits_test.zip)			
Lawrence Rabiner Professor       Isolated digit testing files (raw-ho endpoints marked): (digits_test_raw.zip)         Matlab Files:         Speech Recognition Course       Ioadwav.m: (loadwav.m) savewav.m: (savewav.m) loadraw.m)         Digital Speech Processing Course       Ioadwav.m: (loadwav.m) savewav.m: (savewav.m) loadraw.m)         Processing Course       grayscale.m: (grayscale.m) fxquant.m: (grayscale.m) fxquant.m: (spectrr.m) spectrr.m: (spectrr.m) LPC solutions: (cholesky_full.m), (durbin.m), (lattice.m)         Personal Information AT&T Career Photos       Project Suggestions: General Project Suggestions: (Digital Speech Processing Projects.pdf) LPC Vocoder Project Details: (LPC Vocoder Project.pdf) Project Schedule (UCSB-2009): User Interface Example (Sound Spectrograms): (GUI_plot_spectrogram_ucsb.m), (select_dir.m)         Oded:Material: (oded_material.zip)       T		isolated digit training files (raw-no endpoints marked): (digits_train_raw.zip)			
Professor       Matlab Files:         Bigsech Recognition Course       Ioadwav.m: (loadwav.m) savewav.m: (savewav.m) Ioadraw.m: (loadwav.m) saveraw.m: (savewav.m) Ioadraw.m: (loadwav.m) saveraw.m: (savewav.m) Ioadraw.m: (loadwav.m) saveraw.m: (savewav.m) grayscale.m: (grayscale.m) fxquant.m: (txquant.m) pspect.m: (pspect.m) spectgr.m: (spectgr.m) LPC solutions: (cholesky_full.m), (durbin.m), (lattice.m)         Publications List (Papers and Patents)       Project Suggestions: General Project Suggestions: (Digital Speech Processing Projects.pdf) LPC Vocoder Project Details: (LPC Vocoder Project.pdf) Project Schedule (UCSB-2009): User Interface Example (Sound Spectrograms): (GUL plot_spectrogram_ucsb.m), (select_dir.m)         Oded:Material: (oded_material.zip)       T	Lawrence Rabiner	isolated digit testing files (raw-no endpoints marked): (digits_test_raw.zip)	r		
Home Page       Matlab Files:         Speech Recognition Course       loadwav.m: (loadwav.m) savewav.m: (savewav.m) loadraw.m) savewav.m: (savewav.m) savewav.m: (savewav.m) savetatint (souder Project.pdf) Project Schedule (	Professor		_ [		
Speech Recognition Course       Ioadwav.m: (loadwav.m) savewav.m: (savewav.m) loadraw.m) saveraw.m: (saveraw.m) grayscale.m) fxquant.m: (fxquant.m) pspect.m: (pspect.m) and Patents)         Publications List (Papers and Patents)       grayscale.m) fxquant.m: (fxquant.m) pspect.m: (pspect.m) LPC solutions: (cholesky_full.m), (durbin.m)_ (lattice.m)         Personal Information AT&T Career Photos suzanne Watercolors and Baskets       Project Suggestions: General Project Suggestions: (Digital Speech Processing Projects.pdf) LPC Vocoder Project Details: (LPC Vocoder Project.pdf) Project Schedule (UCSB-2009): User Interface Example (Sound Spectrograms): (GUI_plot_spectrogram_ucsb.m), (select_dir.m)	Home Page	Matlab Files:			
Source       Savewav.m: (savewav.m)         Digital Speech       savewav.m: (savewav.m)         Processing Course       grayscale.m: (grayscale.m)         Publications List (Papers and Patents)       grayscale.m: (spect.m)         Recent Talks       pspect.m: (spectgr.m)         Personal Information       LPC solutions: (cholesky_full.m), (durbin.m), (lattice.m)         AT&T Career Photos       General Project Suggestions:         Suzanne Watercolors and Baskets       General Project Details: (LPC Vocoder Project.pdf)         Project Schedule (UCSB-2009):       User Interface Example (Sound Spectrograms):(GUL plot_spectrogram_ucsb.m), (select_dir.m)         Oded:Material: (oded_material.zip)       T	Speech Recognition	loadway m: (loadway m)			
Digital Speech Processing Course       loadraw.m: (loadraw.m) saveraw.m: (saveraw.m) grayscale.m: (grayscale.m) fxquant.m: (fxquant.m) pspect.m: (pspect.m) spect.m: (pspect.m) spectgr.m) LPC solutions: (cholesky_full.m), (durbin.m), (lattice.m)         Recent Talks         Personal Information AT&T Career Photos Suzanne Watercolors and Baskets         Suzanne Watercolors and Baskets         General Project Suggestions: (Digital Speech Processing Projects.pdf) LPC Vocoder Project Details: (LPC Vocoder Project.pdf) Project Schedule (UCSB-2009): User Interface Example (Sound Spectrograms):(GUI_plot_spectrogram_ucsb.m), (select_dir.m)         Oded:Material: (oded_material.zip)	Course	savewav.m: (savewav.m)			
Digital Speech Processing Course       saveraw.m: (saveraw.m) grayscale.m: (grayscale.m) fxquant.m: (fxquant.m) pspect.m: (pspect.m) spectgr.m: (spectgr.m) LPC solutions: (cholesky_full.m), (durbin.m), (lattice.m)         Recent Talks         Personal Information AT&T Career Photos Suzanne Watercolors and Baskets         Suzanne Watercolors and Baskets         Oded: Material: (oded_material.zip)         Oded: Material: (oded_material.zip)		loadraw.m: (loadraw.m)			
Processing Course       grayscale.m: (grayscale.m)         Publications List (Papers and Patents)       fxquant.m: (fxquant.m)         Pspect.m: (spectgr.m)       pspectgr.m: (spectgr.m)         LPC solutions: (cholesky_full.m), (durbin.m), (lattice.m)         Personal Information         AT&T Career Photos         Suzanne Watercolors and Baskets         Suzanne Watercolors and Baskets         Oded:Material: (oded_material.zip)	Digital Speech	saveraw.m: (saveraw.m)			
Publications List (Papers and Patents)       fxquant.m: (fxquant.m) pspect.m: (pspect.m) spectgr.m: (spectgr.m) LPC solutions: (cholesky_full.m), (durbin.m), (lattice.m)         Recent Talks         Personal Information AT&T Career Photos Suzanne Watercolors and Baskets         Suzanne Watercolors and Baskets         General Project Suggestions: (Digital Speech Processing Projects.pdf) LPC Vocoder Project Details: (LPC Vocoder Project.pdf) Project Schedule (UCSB-2009): User Interface Example (Sound Spectrograms): (GUI_plot_spectrogram_ucsb.m), (select_dir.m)         Oded:Material: (oded_material.zip)	Processing Course	grayscale.m: (grayscale.m)			
Publications List (Papers and Patents)       pspect.m. (pspect.m) spectgr.m: (spectgr.m) LPC solutions: (cholesky_full.m), (durbin.m), (lattice.m)         Recent Talks       Personal Information AT&T Career Photos         Suzanne Watercolors and Baskets       General Project Suggestions: (Digital Speech Processing Projects.pdf) LPC Vocoder Project Details: (LPC Vocoder Project.pdf) Project Schedule (UCSB-2009): User Interface Example (Sound Spectrograms): (GUI_plot_spectrogram_ucsb.m), (select_dir.m)         Oded:Material: (oded_material.zip)       v	Dut lie die state	rxquant.m: (rxquant.m)			
and Faterisy       Specifian: (specifian)         Recent Talks       LPC solutions: (cholesky_full.m), (durbin.m), (lattice.m)         Personal Information       AT&T Career Photos         Suzanne Watercolors and Baskets       General Project Suggestions: (Digital Speech Processing Projects.pdf)         LPC Vocoder Project Details: (LPC Vocoder Project.pdf)         Project Schedule (UCSB-2009):         User Interface Example (Sound Spectrograms): (GUI_plot_spectrogram_ucsb.m), (select_dir.m)         Oded:Material: (oded_material.zip)	Publications List (Papers	spectar m: (spectar m)			
Recent Talks         Personal Information         AT&T Career Photos         Suzanne Watercolors and Baskets         General Project Suggestions: (Digital Speech Processing Projects.pdf)         LPC Vocoder Project Details: (LPC Vocoder Project.pdf)         Project Schedule (UCSB-2009):         User Interface Example (Sound Spectrograms): (GUL plot_spectrogram_ucsb.m), (select_dir.m)         Oded:Material: (oded_material.zip)	and Fatents)	LPC solutions: (cholesky full.m), (durbin.m), (lattice.m)			
Personal Information         AT&T Career Photos         Suzanne Watercolors and Baskets         General Project Suggestions: (Digital Speech Processing Projects.pdf)         LPC Vocoder Project Details: (LPC Vocoder Project.pdf)         Project Schedule (UCSB-2009):         User Interface Example (Sound Spectrograms):(GUI_plot_spectrogram_ucsb.m), (select_dir.m)         Oded:Material: (oded_material.zip)	Recent Talks				
AT&T Career Photos         Suzanne Watercolors and Baskets         General Project Suggestions: (Digital Speech Processing Projects.pdf) LPC Vocoder Project Details: (LPC Vocoder Project.pdf) Project Schedule (UCSB-2009): User Interface Example (Sound Spectrograms):(GUI_plot_spectrogram_ucsb.m), (select_dir.m)         Oded:Material: (oded_material.zip)	Personal Information		-		
AT&T Career Photos       General Project Ouggestions: (Digital Speech Processing Projects.pdf)         Suzanne Watercolors and Baskets       General Project Details: (LPC Vocoder Project.pdf)         Project Schedule (UCSB-2009):       User Interface Example (Sound Spectrograms):(GUI_plot_spectrogram_ucsb.m), (select_dir.m)         Oded:Material: (oded_material.zip)       Image: Comparison of the spectrogram is the		Project Suggestions:			
Suzanne Watercolors and Baskets       General Project Suggestions: (Digital Speech Processing Projects.pdf) LPC Vocoder Project Details: (LPC Vocoder Project.pdf) Project Schedule (UCSB-2009): User Interface Example (Sound Spectrograms):(GUI_plot_spectrogram_ucsb.m), (select_dir.m)         Oded:Material: (oded_material.zip) <ul> <li>Image: Comparison of the spectrogram is a spectrogram in the spectrogram in the spectrogram is a spectrogram in the spectrogram is a spectrogram in the spectrogram is a spectrogram in the spectrogram in the spectrogram is a spectrogram in the spectrogram is a spectrogram in the spectrogram is a spectrogram in the spectrogram in the spectrogram is a spectrogram in the spectrogram is a spectrogram in the spectrogram in the spectrogram is a spectrogram in the spectrogram in the spectrogram is a spectrogram in the spectrogram</li></ul>	AT&T Career Photos				
Image: State in the treated states       LPC Vocoder Project Details: (LPC Vocoder Project.pdf)         Image: State in the treated states       Project Schedule (UCSB-2009):         User Interface Example (Sound Spectrograms):(GUI_plot_spectrogram_ucsb.m), (select_dir.m)         Oded:Material: (oded_material.zip)	Suzanne Watercolors	General Project Suggestions: (Digital Speech Processing Projects.pdf)			
Project Schedule (UCSB-2009):     User Interface Example (Sound Spectrograms):(GUI_plot_spectrogram_ucsb.m), (select_dir.m)     Oded:Material: (oded_material.zip)	and Baskets	LPC Vocoder Project Details: (LPC Vocoder Project.pdf)			
Oded:Material: (oded_material.zip)	and Daskets	Project Schedule (UCSB-2009): User Interface Example (Sound Spectrograms): (CLII, plot, spectrogram, useb m), (select, dirm)			
✓     Oded:Material: (oded_material.zip)		User interface Example (Sourio Spectrograms). (GOL_plot_spectrogram_ucsp.m), (select_dlr.m)			
	7	Oded:Material: (oded_material.zip)	Ţ		
DUIE	Done	·			

Download MATLAB (.m) files; Examine Project Suggestions

### **Course Readings**

**Required Course Textbook:** 

• L. R. Rabiner and R. W. Schafer, Theory and Applications of Digital Speech Processing, Prentice-Hall Inc., 2011

#### **Recommended Supplementary Textbook:**

• T. F. Quatieri, *Principles of Discrete - Time Speech Processing,* Prentice Hall Inc, 2002

#### Matlab Exercises:

- C. S. Burrus et al, Computer-Based Exercises for Signal Processing using Matlab, Prentice Hall Inc, 1994
- J. R. Buck, M. M. Daniel, and A. C. Singer, Computer Explorations in Signals and Systems using Matlab, Prentice Hall Inc, 2002

### **Recommended References**

- J. L. Flanagan, Speech Analysis, Synthesis, and Perception, Springer -Verlag, 2<sup>nd</sup> Edition, Berlin, 1972
- J. D. Markel and A. H. Gray, Jr., *Linear Prediction of Speech*, Springer-Verlag, Berlin, 1976
- B. Gold and N. Morgan, *Speech and Audio Signal Processing,* J. Wiley and Sons, 2000
- J. Deller, Jr., J. G. Proakis, and J. Hansen, *Discrete Time Processing of Speech Signals,* Macmillan Publishing, 1993
- D. O'Shaughnessy, Speech Communication, Human and Machine, Addison-Wesley, 1987
- S. Furui and M. Sondhi, *Advances in Speech Signal Processing,* Marcel Dekker Inc, NY, 1991
- R. W. Schafer and J. D. Markel, Editors, *Speech Analysis*, IEEE Press Selected Reprint Series, 1979
- D. G. Childers, *Speech Processing and Synthesis Toolboxes,* John Wiley and Sons, 1999
- K. Stevens, Acoustic Phonetics, MIT Press, 1998
- J. Benesty, M. M. Sondhi and Y. Huang, Editors, Springer Handbook of Speech Processing and Speech Communication, Springer, 2008.

#### References in Selected Areas of Speech Processing

**Speech Coding:** 

- A. M. Kondoz, Digital Speech: Coding for Low Bit Rate Communication Systems-2<sup>nd</sup> Edition, John Wiley and Sons, 2004
- W. B. Kleijn and K. K. Paliwal, Editors, Speech Coding and Synthesis, Elsevier, 1995
- P. E. Papamichalis, *Practical Approaches to Speech Coding,* Prentice Hall Inc, 1987
- N. S. Jayant and P. Noll, *Digital Coding of Waveforms,* Prentice Hall Inc, 1984

**References in Selected Areas of Speech Processing** 

#### **Speech Synthesis**:

- T. Dutoit, An Introduction to Text To-Speech Synthesis, Kluwer Academic Publishers, 1997
- P. Taylor, Text-to-Speech Synthesis, Cambridge University Press, 2008
- J. Allen, S. Hunnicutt, and D. Klatt, *From Text to Speech,* Cambridge University Press, 1987
- Y. Sagisaka, N. Campbell, and N. Higuchi, *Computing Prosody*, Springer Verlag, 1996
- J. VanSanten, R. W. Sproat, J. P. Olive and J. Hirschberg, Editors, *Progress in Speech Synthesis*, Springer Verlag, 1996
- J. P. Olive, A. Greenwood, and J. Coleman, *Acoustics of American English,* Springer Verlag, 1993

#### References in Selected Areas of Speech Processing

**Speech Recognition**:

- L. R. Rabiner and B. H. Juang, Fundamentals of Speech Recognition, Prentice Hall Inc, 1993
- X. Huang, A. Acero and H-W Hon, Spoken Language Processing, Prentice Hall Inc, 2000
- F. Jelinek, *Statistical Methods for Speech Recognition,* MIT Press, 1998
- H. A. Bourlard and N. Morgan, Connectionist Speech Recognition-A Hybrid Approach, Kluwer Academic Publishers, 1994
- C. H. Lee, F. K. Soong, and K. K. Paliwal, Editors, *Automatic Speech and Speaker Recognition*, Kluwer Academic Publisher, 1996

#### **References in Digital Signal Processing**

- A. V. Oppenheim and R. W. Schafer, *Discrete Time Signal Processing*, 3<sup>rd</sup> Ed., Prentice-Hall Inc, 2010
- L. R. Rabiner and B. Gold, *Theory and* Application of Digital Signal Processing, Prentice Hall Inc, 1975
- S. K. Mitra, *Digital Signal Processing-A Computer-Based Approach*, Third Edition, McGraw Hill, 2006
- S. K. Mitra, *Digital Signal Processing Laboratory Using Matlab,* McGraw Hill, 1999

### **The Speech Stack**

**Speech Applications** — coding, synthesis, recognition, understanding, verification, language translation, speed-up/slow-down

**Speech Algorithms**— speech-silence (background), voiced-unvoiced, pitch detection, formant estimation

Speech Representations — temporal, spectral, homomorphic, LPC

*Fundamentals* — acoustics, linguistics, pragmatics, speech production/perception

### **Digital Speech Processing**



# Need to understand speech processing at all three levels

#### **Course Outline – ECE 259A – Speech Processing**

- Jan 8 Lecture 1, Basic Course Material; Introduction to Digital Speech Processing
- Jan 10 Lecture 2a, Review of DSP Fundamentals
- Jan 15 Lecture 2b, Review of DSP Fundamentals
- Jan 17 Lecture 3a, Acoustic Theory of Speech Production
- Jan 22 Lecture 3b, Lecture 4, Speech Perception—Auditory Models
- Jan 24 Lecture 5, Sound Propagation in the Vocal Tract -- Part 1
- Jan 29 Lecture 6, Sound Propagation in the Vocal Tract -- Part 2
- Jan 31 Lecture 7, Time Domain Methods -- Part 1
- Feb 5 Lecture 8, Time Domain Methods -- Part 2
- Feb 7 Lecture 9, Frequency Domain Methods -- Part 1
- Feb 12 Lecture 10-11, Frequency Domain Methods -- Part 2
- Feb 14 Mid Term Exam
- Feb 19 Lecture 12a, Homomorphic Speech Processing -- Part 1
- Feb 21 Lecture 12b, Homomorphic Speech Processing -- Part 2
- Feb 26 Lecture 13, Linear Predictive Coding (LPC) -- Part 1
- Feb 28 Lecture 14, Linear Predictive Codeing (LPC) -- Part 2
- Mar 5 Lecture\_Algorithms
- Mar 7 Lecture 15, Speech Waveform Coding -- Part 1
- Mar 12 Lecture 16, Speech Waveform Coding -- Part 2
- Mar 14 Term Project Presentations (8-12 noon)
- Mar 19 Final Exam (8 am-11 am)

# Other Potential Topics for Discussion/Term Projects

- Sinusoidal modeling of speech
- Speech modification and enhancement slowing down and speeding up speech, noise reduction methods
- Speaker verification methods
- Music coding including MP3 and AAC standards-based methods
- Pitch detection methods

### **Term Project**

- All registered students are required to do a term project. This term project, implemented **using Matlab**, must be a speech or audio processing system that accomplishes a simple or even a complex task—e.g., pitch detection, voiced-unvoiced detection, speech/silence classification, speech synthesis, speech recognition, speaker recognition, helium speech restoration, speech coding, MP3 audio coding, etc.
- Every student is also required to make a 10-minute Power Point *presentation* of their term project to the entire class. The presentation must include:
  - A short description of the project and its objectives
  - An explanation of the implemented algorithm and relevant theory
  - A demonstration of the *working* program i.e., results obtained when running the program

### **Suggestions for Term Projects**

- 1. Pitch detector time domain, autocorrelation, cepstrum, LPC, etc.
- 2. Voiced/Unvoiced/Silence detector
- 3. Formant analyzer/tracker
- 4. Speech coders including ADPCM, LDM, CELP, Multipulse, etc.
- 5. N-channel spectral analyzer and synthesizer phase vocoder, channel vocoder, homomorphic vocoder
- 6. Speech endpoint detector
- 7. Simple speech recognizer e.g. isolated digits, speaker trained
- 8. Speech synthesizer serial, parallel, direct, lattice
- 9. Helium speech restoration system
- 10. Audio/music coder
- 11. System to speed up and slow down speech by arbitrary factors
- 12. Speaker verification system
- 13. Sinusoidal speech coder
- 14. Speaker recognition system
- 15. Speech understanding system
- 16. Speech enhancement system (noise reduction, post filtering, spectral flattening)

### **MATLAB Computer Project**

The requirements for this project are a short description of the problem containing relevant mathematical theory and objectives of the project, a listing (with sufficient documentation and comments) of the program, and a demonstration that the program works properly.