LING 490 - SPECIAL TOPICS IN LINGUISTICS

Fundamentals of Digital Signal Processing

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Week 1

Instructors and office hours

- Yan Tang, Assistant Professor
  - yty@Illinois.edu
  - Walk-in: 2-3 pm, Friday
  - By appointment: 10-11am, Thursday
  - FLB 4023
- Shuju Shi, Teaching Assistant
  - shujus2@illinois.edu
  - 10-11 am, Tuesday
  - FLB 4036

Course website

- https://uiuc-ling-cl.github.io/ling490_dsp/

DRES

If a student has a disability or condition that requires special consideration, the student is expected to present the requisite letter from the University Division of Disability Resources and Educational Services (DRES) no later than the beginning of the second week of class.

Academic integrity

This course follows the University of Illinois Student Code regarding Academic Integrity. The College of Liberal Arts and Sciences also has an excellent web page on the topic. You are expected to read these resources prior to the second day of class, and to understand your responsibilities regarding Academic Integrity.

All work submitted for this class must be solely your own. Violations of Academic Integrity include, but are not limited to, copying, cheating, and unapproved collaboration.

Asking questions and discussion

- Course Piazza site linked off course web page
- Verify that you are enrolled in the course Piazza site
- Ask questions via Piazza
- Do not ask questions via email

Sign up: https://piazza.com/illinois/spring2020/ling490

Home: https://piazza.com/illinois/spring2020/ling490/home

Other business

- https://uiuc-ling-cl.github.io/ling490_dsp/syllabus.html
- Student responsibilities
- Absences and late work policy
- etc...

Course Overview

- Concepts and principles of digital signal processing (DSP)
- DSP in the time and frequency domain
- Speech parameter extraction algorithms
- Doing DSP with Python
- Focus: practical implementations and algorithms

More details: https://uiuc-ling-cl.github.io/ling490_dsp/schedule.html

Objectives

- To have a broad understanding on DSP and techniques
- To be able to perform basic DSP using Python
- To be able to implement small applications of the techniques in practice
- To develop self-learning and problem-solving abilities

Course schedule

- Monday: lecture
- Wednesday: lecture, discussion and demo
- Friday: lab session

Evaluation

- Lecture attendance, lab exercises and mid-term assessment:
  - Attendance: **10%**
  - Mid-term assessment: **10%**
  - Lab exercise: **30%**
- After-class homework and final project
  - Bi-weekly homework: **30%**
  - Final project: **20%**
- A total of **100%**

Essentials: students

- Python programming skills
  - Not a dedicated course for learning programming!
- Basic git commands
  - *clone*, *add*, *commit*, *pull* and *push*
- Can survive from exposure of simple math equations and formulas
  - We focus more on what and how, less why…

Essentials: hard- and software

- i>clicker
- Functional computer
- Python 3
  - Anaconda distribution: https://www.anaconda.com/distribution/
  - numpy, scipy, matplotlib and seaborn
- Git
  - Mac users: do nothing
  - Window users: https://git-scm.com/download/win

https://uiuc-ling-cl.github.io/ling490_dsp/syllabus.html

Introduction of DSP

- Have you heard of DSP?
- Can you think of any examples of DSP?

Applications of DSP

Instagram

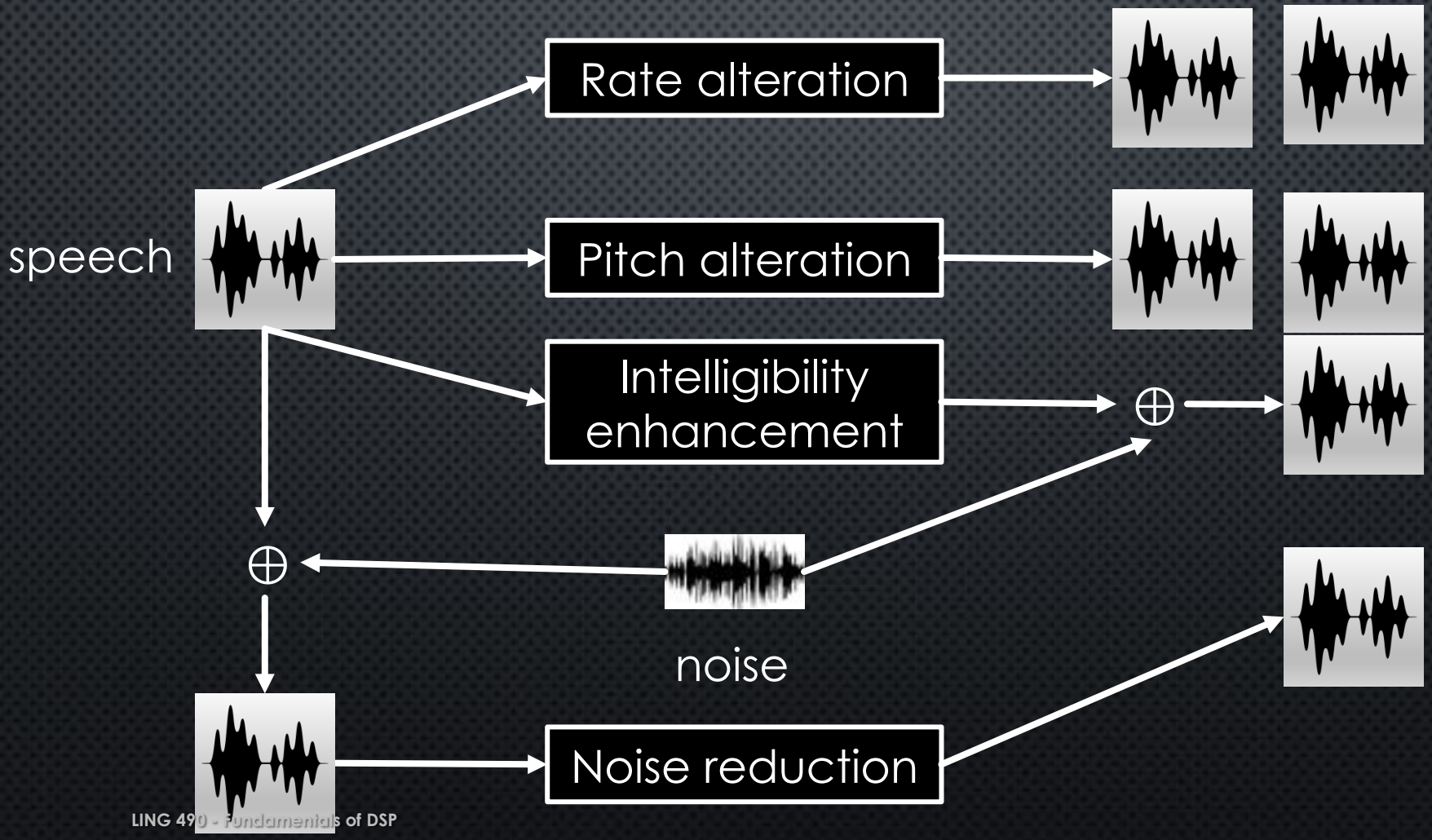
Why study DSP?

- Basis of signal acquisition issues (e.g. during corpus collection)
  - Clipping
  - Quantisation
  - Aliasing
- Terminology
  - e.g. “filters”, “SNR”, “spectral tilt”, “impulse response”, “linear prediction”, “cepstrum”, ...
- When to use certain techniques
  - LPC-based formant analysis
  - Auto-correlation

Why study DSP (contd.)?

- How to get more out of tools such as PRAAT
  - Why changing a window size/shape helps
  - Choosing number of formants
- Understanding how a spectrogram is made
- Why we use certain techniques
  - Preemphasis
- What to do when faced with poor recordings
- When to trust 3rd party code
  - They are not always reliable!

Examples: speech signal manipulations



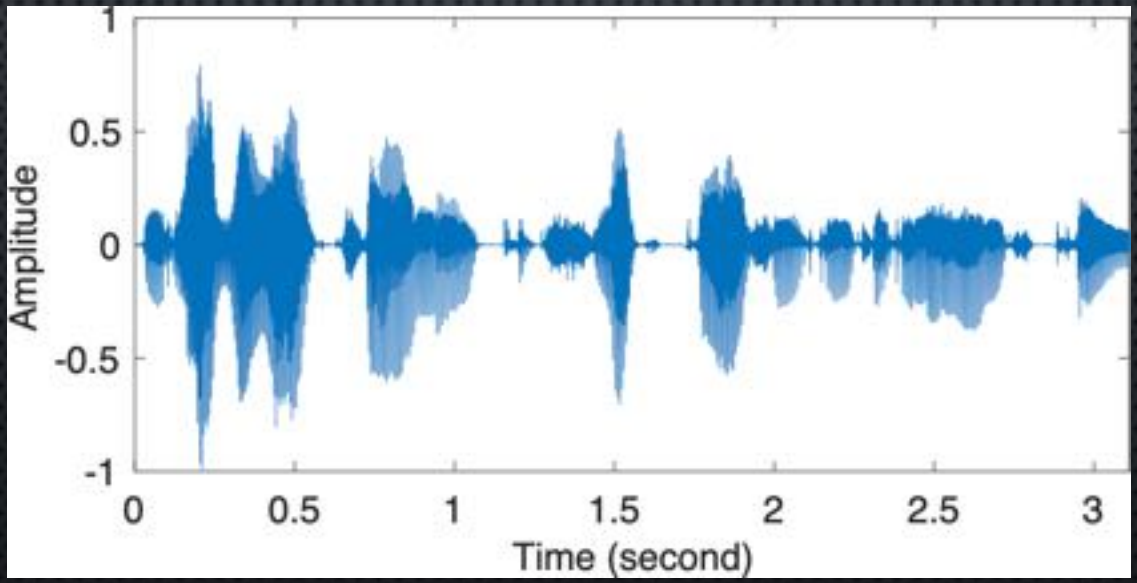
Examples: speech signal manipulations

Signals I

- What is a signal?
  - Any quantity (e.g. temperature) that varies with some independent variable (e.g. time)
- We can often describe signals mathematically
- Signals can be 1-dimensional (audio), 2-D (image), or 3-D (a movie)

Signals II

- Some signals are too complicated to be described mathematically



Signals III

- Most signals are analogue or continuous.
  - e.g. pressure, light, vibration, voltage, force, etc
  - For a continuous signal $s(t)$, we can find the value of s at any point in time.
  - These signals can be processed directly using analogue systems.

- Useful to turn these continuous signals into digital signals.

Question

- Which of these signals are continuous time and which are discrete time?

1. A jpeg image
2. Acoustic pressure
3. Voltage
4. Audio stored on a CD

Analog vs Digital

Analog

+ fast, well-behaved, degrades gracefully
- incompatible with the computer/digital age
- needs special hardware
- practical limits to signal processing

Digital

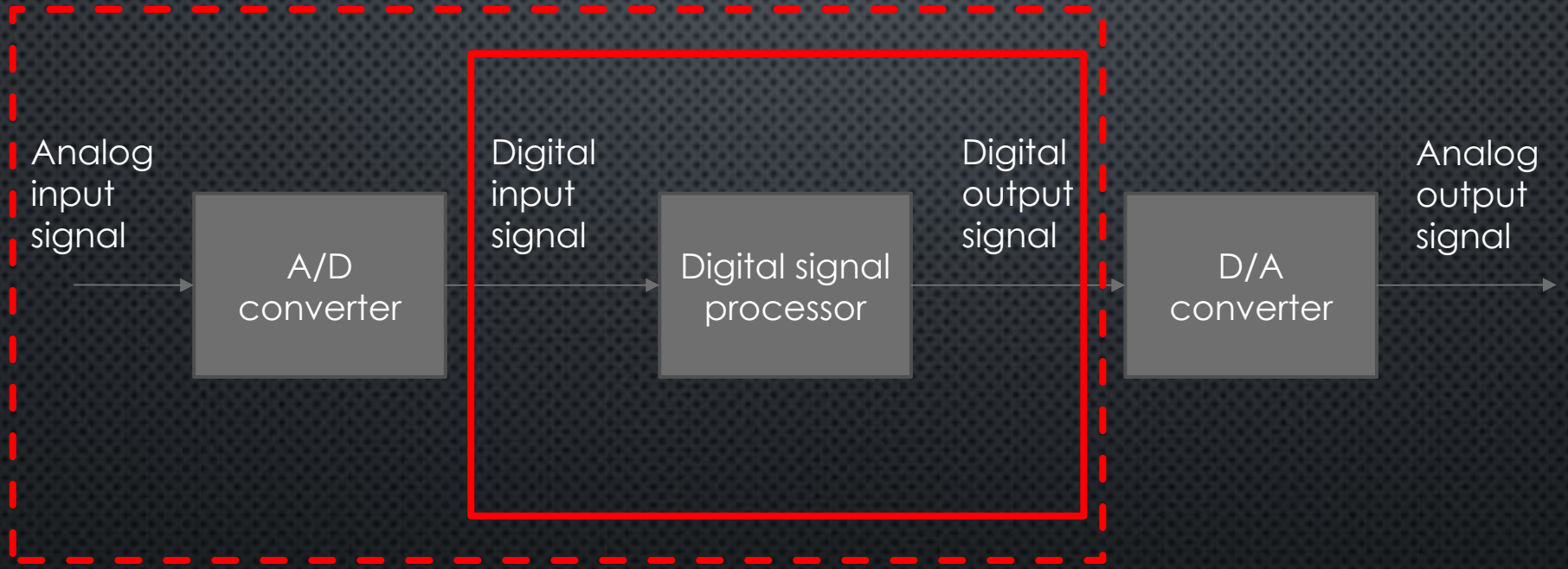
+ virtually unlimited processing without specialist hardware (just a computer)
+ can employ error-correcting codes
- needs care in acquisition
- slow to process; potential for loss of information

Analog vs Digital

Analog vs Digital

https://www.pinterest.com/pin/484418503664576260/
https://www.presonus.com/learn/technical-articles/How-To-Set-Up-a-Home-Recording-Studio

Workflow of DSP systems



Three fundamental ideas of DSP

- Any signal can be represented using a finite number of discrete data points over time.
- Any signal can be broken down into a stream of bits that can be stored, generated and manipulated by a computer
- Any (practical) signal can be represented as the sum of sinusoids (or complex exponentials)

Friday: lab session