Administrivia:

Lecture slides will be posted at:


- Instructors
  - Gary Bishop, gb@cs.unc.edu, 2-1886
  - Leandra Vicci, vicci@cs.unc.edu, 2-1742
- TA will be
  - Matt Waibel, waibel@cs.unc.edu, 2-1959
- Textbook –
  The Scientist and Engineer’s Guide to Digital Signal Processing,
  Steven W. Smith, ISBN 0-9660176-3-3, LCCN 97-80293, c.1997,
  California Technical Publishing, San Diego, CA 92150-2407,
  http://www.DSPguide.com
- Where/when should we meet
  - 027SN Hardware Teaching Lab
  - time TBD
- Labs
  - TBD
- Wei-Chao Chen and Kok-Lim Low – we want your pictures
  - [see Claire Stone (stonec) or bring us your own]
What we hope you will get out of it:

• A broader view of information processing
• Choice of appropriate technology
• Hardware systems is not necessarily hardware design
• Solving the problem often involves physical understanding
• The usefulness and value of formal mathematical models
• A general feel for system building methodology
• A "spiral" approach to design (Sequin)
• Hands-on lab skills in various technologies
• The devil is in the details: you manufacture your own luck
• The thrill of victory or the agony of defeat
Course plan:

- Pose an unsolved problem (we think we can solve)
- Provide conceptual tools and background (lectures, lab)
- Ask you to propose plausible solutions (homework)
- Compare and critique proposed solutions (class discussion)
- Formulate abstract design (class discussion)
- Define project goals and specifications (formalize things)
- Develop functional design (high level design)
- Logically decompose the design (abstract → concrete)
Course plan (continued):

- Evaluate implementation technologies (lectures, labs)
- Partition the system by technologies (lectures)
- Develop testing plan (component, subsystem, and system)
- Define implementation modules (project plan)
- Design, construction and test plan for each module (homework)
- Assign project modules (class discussion)
- Implement modules (class discussions and labs)
- System integration and test (labs)
- Proof of concept demonstration (Public demo)
Quick tour of the horizon:

• Abstract overview of the whole thing

• This will be very cursory (just an overview)

• Important ideas will be revisited in detail

• But listen up now (homework is based on this material)
The problem motivation:

- Undesired feedback in Public Address (PA) systems (= the problem)

- You have all experienced shrieks, squeaks and howls

- Vern’s court room experience in 1995 (anecdotic)

- Adaptive echo cancellation in telephony (plausible approach)
Feedback theory once over lightly:

- The feedback loop
- The loop gain, G
- Phase shift around the loop (G is complex)
- Positive vs. negative feedback (accuracy vs. oscillation)
- The instability condition (G = 1 is magic)
- Nearly unstable loops (”ringing” at certain frequencies)
- Nonlinear loops are different (we won’t go there!)
The PA system and its environment:

- The loop model (system comprises multiple domains)
- The electrical domain (amplifier)
- The transducers (microphone, loudspeakers)
- The acoustic domain (the environment)
- Multipath (magnitudes and phase shifts)
- Linear superposition (aggregate microphone signal)
The relevant acoustics:

- Sound pressure waves in air (the wave equation)
- Reflections from objects (impedance discontinuity)
- The speed of sound (delay $\rightarrow$ phase shift)
- Linearity assumption (air and objects)
- Waves and rays (simplifying approximation)
Reading assignment:
Chapter 1 of Smith, Audio Processing
Homework assignment:

We have given you enough to brainstorm possible solutions to the problem. Assume the solution is a process to be inserted in the electrical domain (e.g., between the microphone and the amplifier) which will suppress the loop feedback sufficiently to prevent shrieks, squeals, howls, and perceptible ringing. Don’t worry about details of implementation here. Think just in behavioral terms, explaining them at least somewhat formally; that is, use concepts of delay, phase shift, subtraction, magnitude, etc. in at least a qualitative way. Propose your ideas in a form that can be discussed in class. DUE next time! Hint: can you use an electrical analogue which models the acoustic environment? What would such a model look like? How could you use such a model to help suppress the unwanted behavior?