



VISUALIZATION OF SIGNAL PROCESSING CONCEPTS

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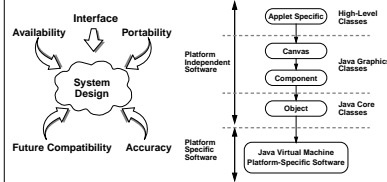
Motivation

- Hands-on learning capabilities help reinforce classroom instruction
- Visualization of many abstract concepts involved in signal processing
- Speech recognition research requires a mastery of many fundamental concepts

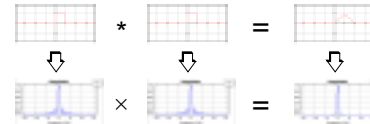


Java Approach

- Coded to strict ISIP programming standards for object-oriented design



Spectral Analysis Example



- A quick illustration of the principle that convolution in the time domain is equivalent to multiplication in the frequency domain
- Interactive exploration of theorems

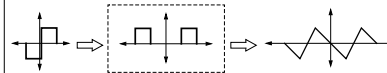
Conclusions

- First step towards a comprehensive set of tools for use in undergraduate signal processing courses
- Learning on demand approach more efficient (student feedback is very positive)
- Reinforce homework assignments with an on-line tutor capable of providing solutions
- Publicly available to anyone with a Java capable browser

Other Approaches

- Matlab — Numeric Processing**
 - Built-in routines allow fast prototyping of applications
 - Requires a commercial product to run utilities
 - Requires that copies of the interface be kept on user's machine
 - Lacks accessibility for many students
- MathCAD — Mathematical Notation Interface**
 - Lacks a mature interface for interactive utilities
 - Limited number of supported platforms
 - Requires a commercial product to interface tools
- Ptolemy — Flow-Graph System Analysis**
 - Well-refined and specialized tools for system analysis
 - Available only for Unix platforms; excludes a large student population
- Visual C++ or Visual Basic — Programming**
 - Available for only a limited number of platforms
 - Software must be compiled on local computer
 - Requires extensive knowledge of programming languages

Convolution



- Core concept in Signal Processing
- Graphical convolution is a prime example of the use of visualization techniques to understand a complex integral expression
- The visualization of graphical convolution is itself a difficult concept for students

Pole/Zero



- Eliminate need to visualize 3D and 4D surfaces
- Pole/zero analysis is integral to linear system design
- Allows exploration of pole/zero interactions

Future Plans

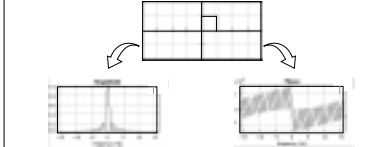
- Additional applets dealing with:
 - Filter Design
 - Nyquist Criterion
 - Linear discriminant analysis
 - Principal components analysis
 - Support vector machines
 - Hidden Markov models
 - Formants and real-time spectrograms
- Interactive exploration of all components of a speech recognition system
- Ability to run small speech recognition experiments over the web

Why Java?



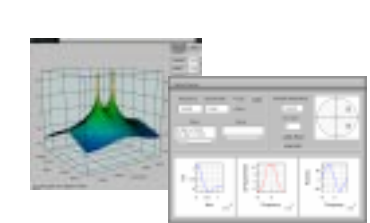
- Good platform for interactive speech technology through its Speech API

Spectral Analysis



- A fundamental analysis tool
- Understanding the relationship between the time and frequency domains at an intuitive level is critical to linear systems analysis

Pole/Zero Example



Example: HMM Concepts

- Demonstrates:**
 - discrete HMM concepts
 - Viterbi vs. Baum-Welch
 - synthesis of data
 - model fitting and prediction
 - model verification
- Incremental progress towards:**
 - an educational tool for pattern matching and speech recognition
 - public domain speech recognition software
 - Internet accessible speech recognition technology