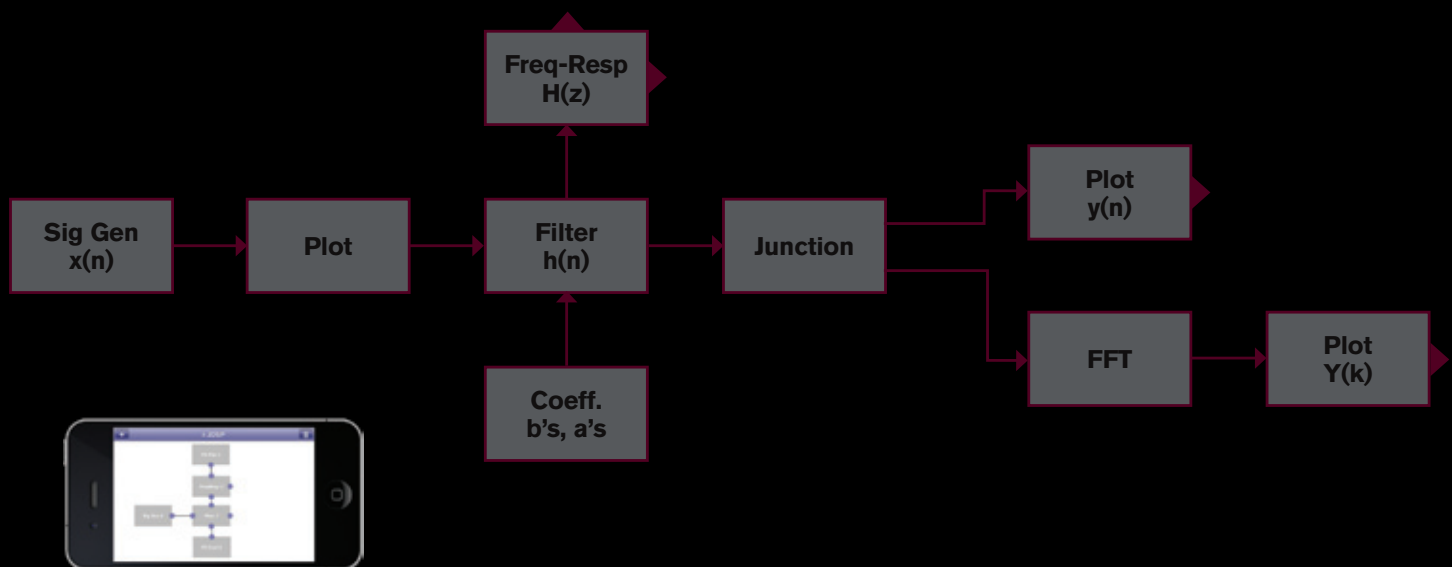




## Java - Digital Signal Processing

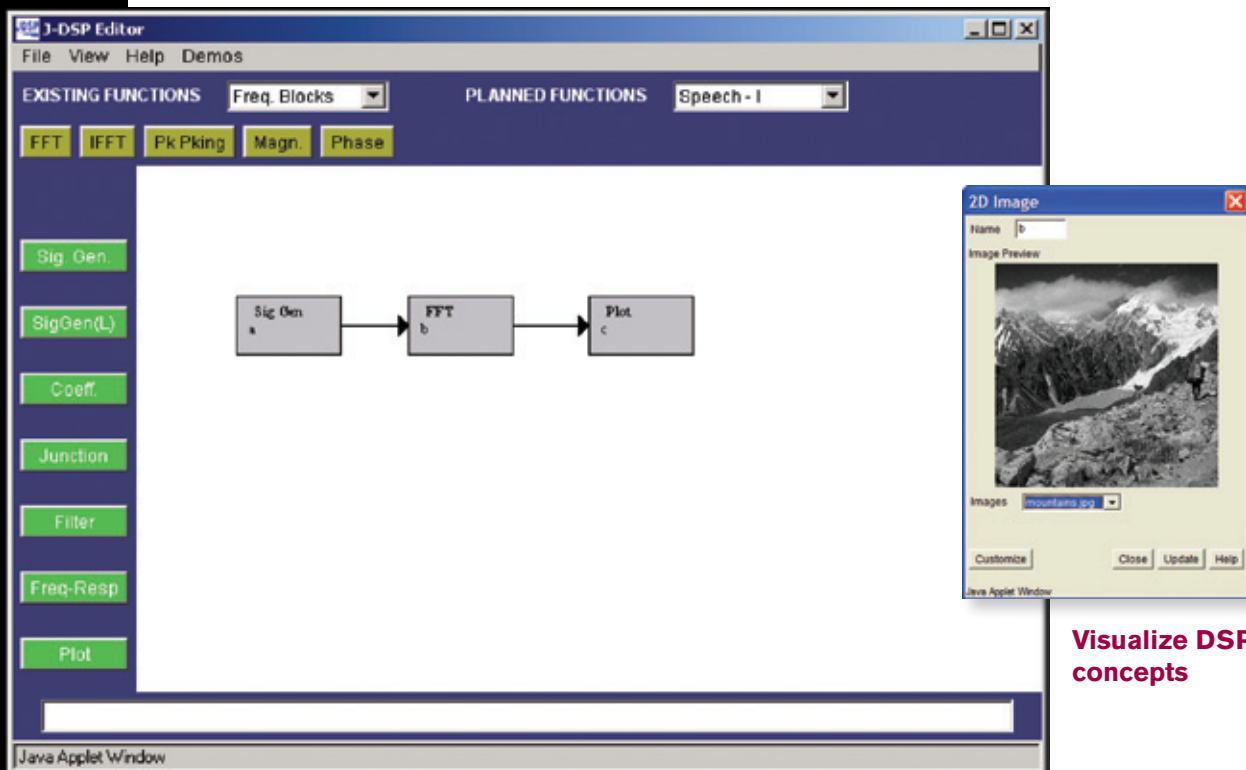
An Online Signal Processing Simulation Tool



<http://jdsp.asu.edu>

## About the J-DSP Editor

Java-DSP (J-DSP) is an educational software package for online simulations and web-based computer laboratories. J-DSP is based on an object-oriented visual programming environment that enables students to establish and run DSP simulations on the Internet. This universally accessible tool is based on an intuitive “block diagram” programming approach. J-DSP has been developed specifically for education; several functions have been inspired by interactions with students to explain concepts that were not evident with blackboard-type explanations. The functions that J-DSP supports are suitable for basic DSP tutoring as well as for demonstrating advanced algorithms. Basic functions include signal generators, arithmetic functions, convolution, filtering, the FFT, impulse and frequency response plots, etc. Advanced functions include statistical and multirate DSP, fixed-point and PCM quantization blocks, select MPEG-Layer 3 functions, and hidden Markov model (HMM) estimation. More on J-DSP functions and their assessment can be found in: A. Spanias, V. Atti, “Interactive online undergraduate laboratories using “J-DSP,” IEEE Transactions on Education, vol. 48, no. 4, pp. 735- 749, Nov. 2005.



**Visualize DSP concepts**

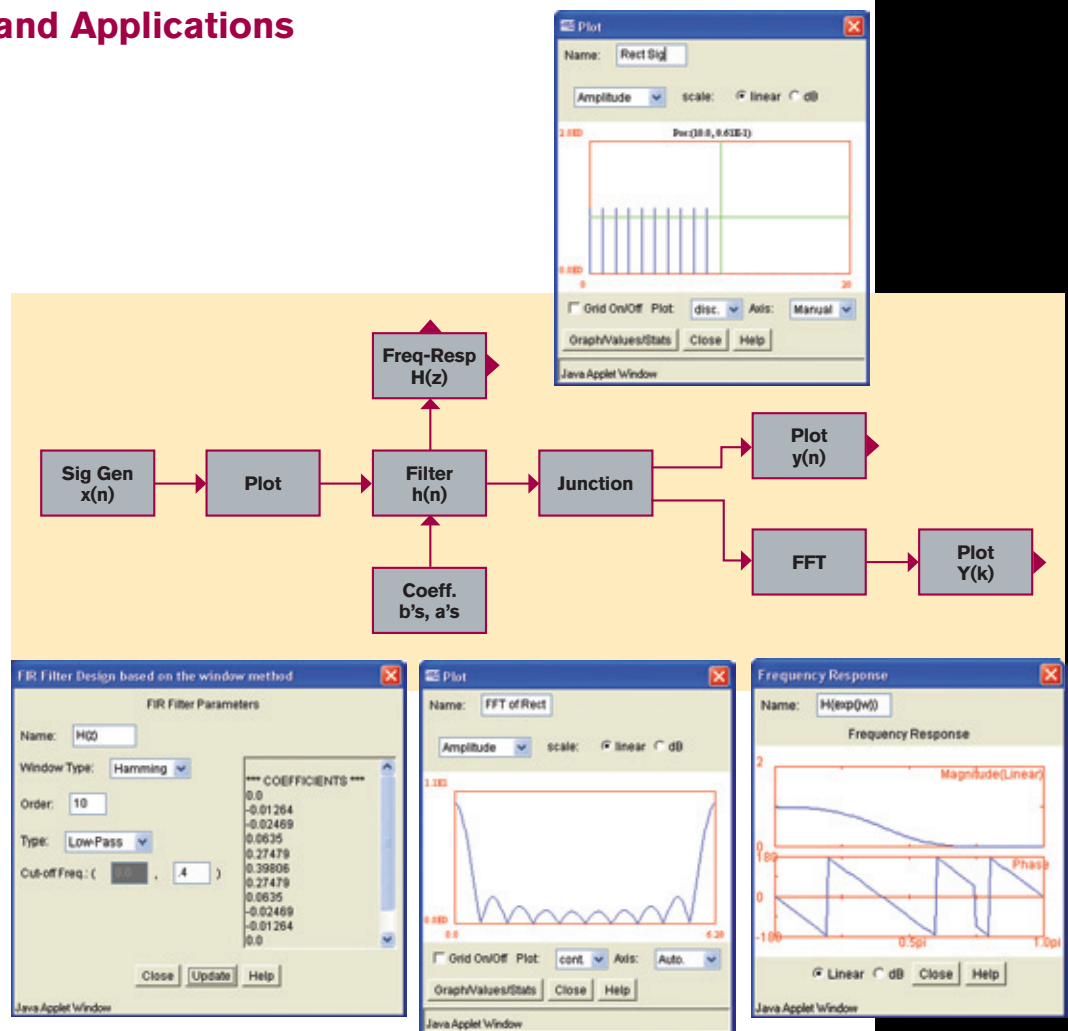
### J-DSP is universally and freely accessible

- J-DSP is an on-line graphical DSP simulator written as a Java applet.
- Users can obtain graphical or numerical results at any point of the simulation.
- Provides a simple graphical and user-friendly interface.
- J-DSP has won national awards and ranked as one of the top 3 non-commercial education software resources by NEEDS in 2003.
- J-DSP is also being used in sensor networks research.
- J-DSP is used in earth systems and geology.
- A J-DSP arts and media functions suite is being developed.
- J-DSP interfaces with DSP hardware have been established.
- A functional MP3 decoder in J-DSP has been tested.
- Ion-channel models in J-DSP for sensor applications have been formed.

# J-DSP Functionality and Applications

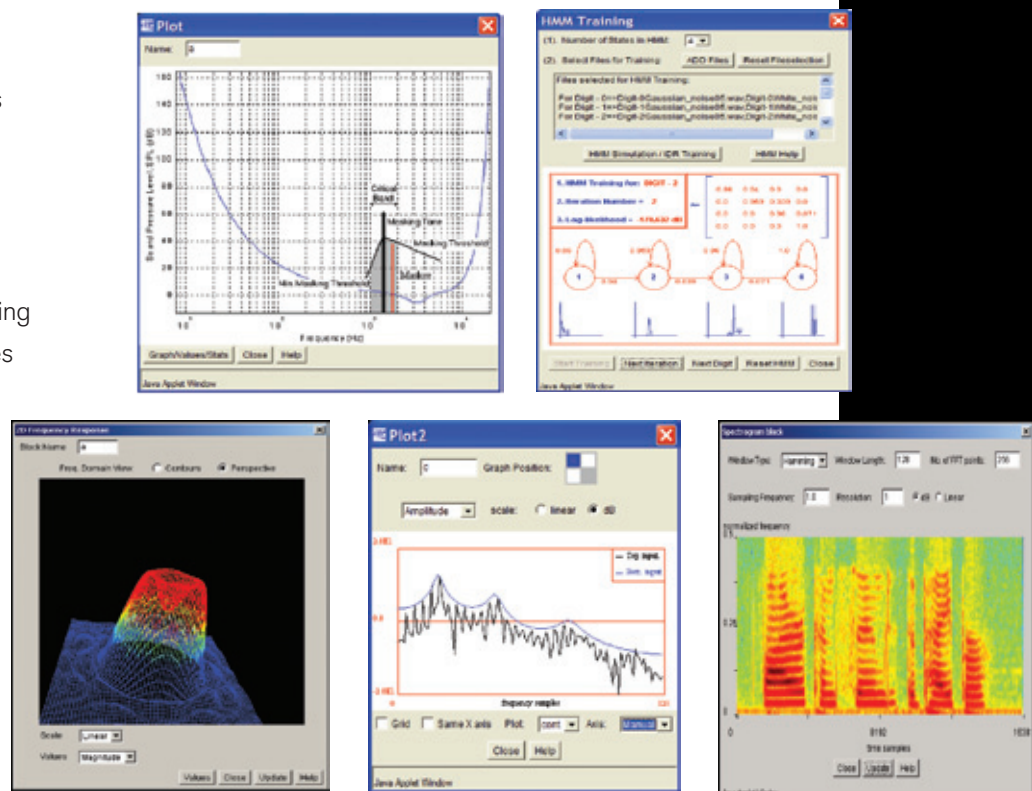
## Basic Functions

- Fundamental DSP Functions (FFT, IFFT, Windowing etc)
- Basic Arithmetic Functionality
- Multi-rate DSP
- Pole-Zero z-domain diagrams
- Frequency Response
- Visualization Blocks
- Digital Filtering
- FIR/IIR Filter Design
- Spectral Estimation
- 3D Animations
- Signal to noise ratio
- Spectrogram
- Visual impulse response design
- Quantization functions
- Parametric methods



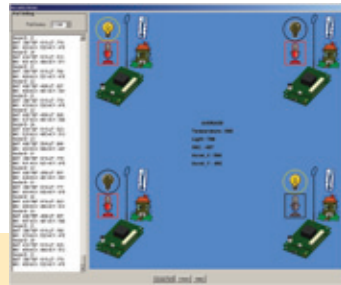
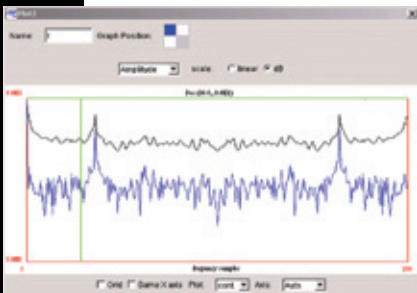
## Advanced Functions

- Analog and Digital Communications
- Control Systems
- Image and 2D Signal Processing
- Speech Analysis and Synthesis
- Time/Frequency Representations
- Hidden Markov Model (HMM) Training
- Perceptual Audio Coding Techniques
- Genomic Signal Processing
- Adaptive Signal Processing
- Beamforming Applications



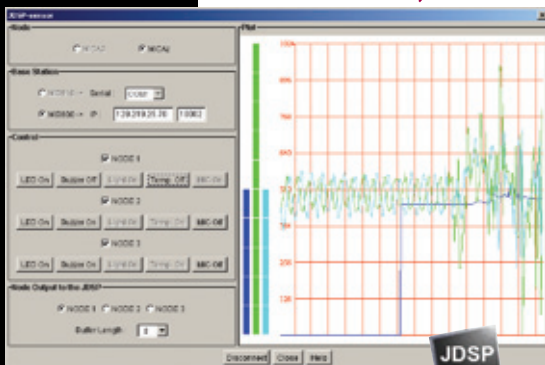
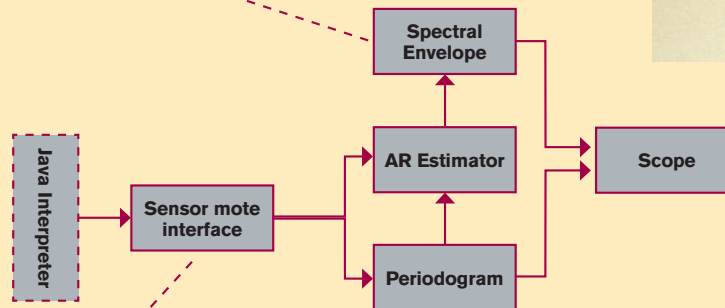
# J-DSP and Sensor Networks

## Remote sensing enabled by J-DSP



Remote sensing hardware set-up

Java Interfaces with Tiny OS using nesC language

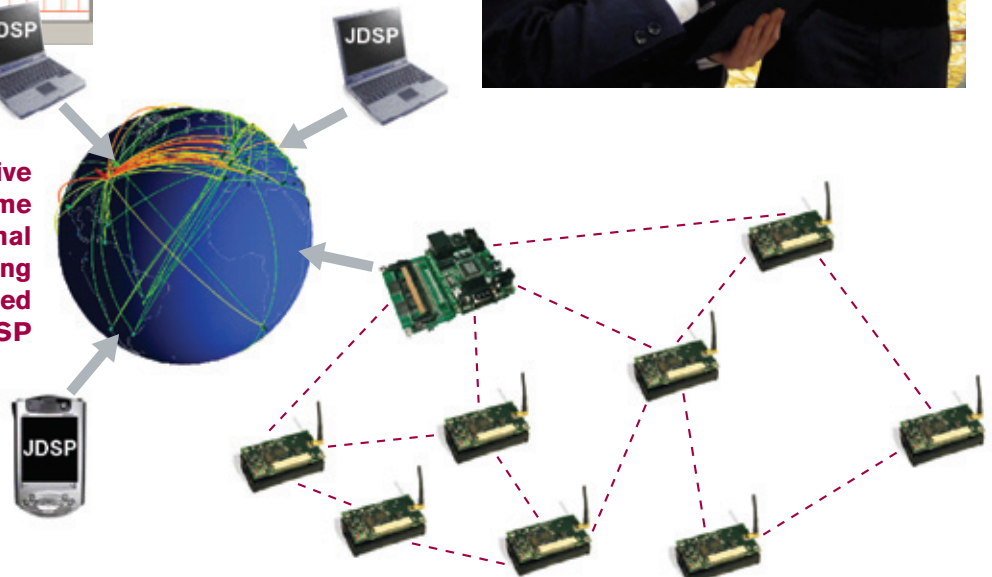


## Applications

- Environmental Monitoring
- Acoustic Monitoring
- Security
- Source Localization
- Tracking
- Biological Applications



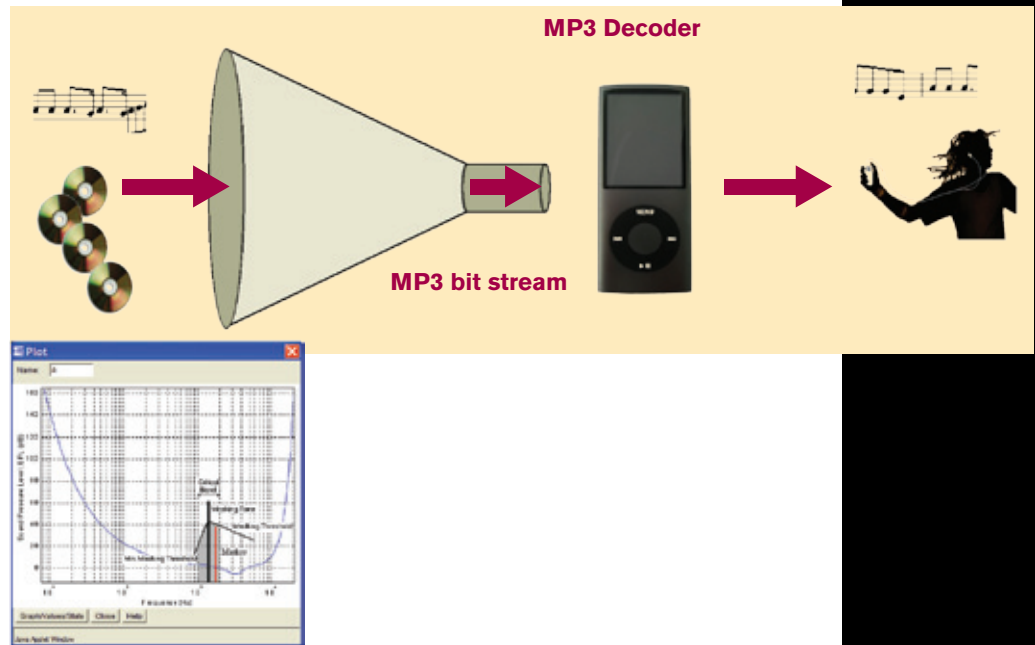
Collaborative Real-Time Sensor Signal Processing Enabled by J-DSP





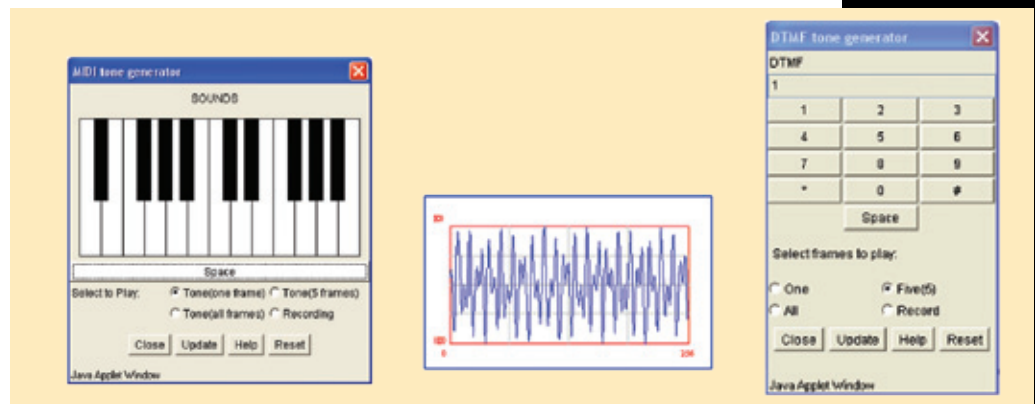
## Learning the basics of MP3 compression using J-DSP

- Critical band analysis
- Tonal and noise making experiments
- MPEG-1 psychoacoustics model-1 implementation



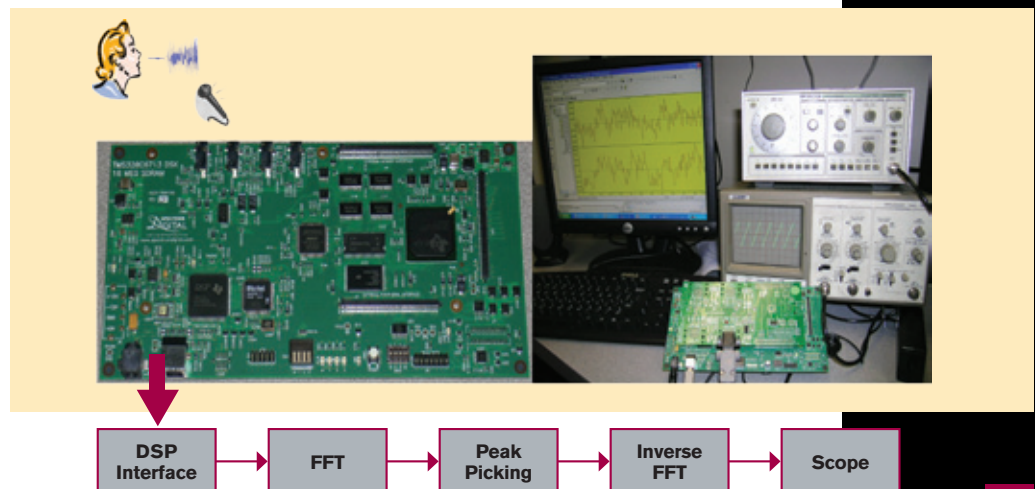
## J-DSP piano player and phone dialing functions

- J-DSP can be used to introduce signals and systems in freshman and senior high school classes.
- Tone-generators
- MIDI encoder
- DTMF encoder
- Echo and Reverberation Effects



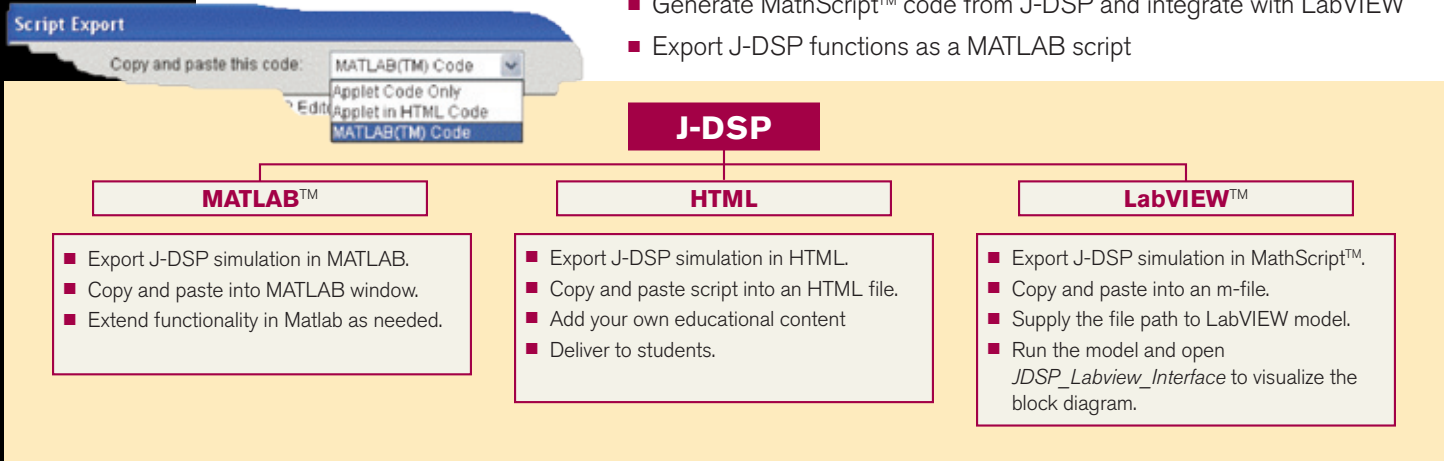
## J-DSP Interface with DSP Boards

- Real-time experiments with J-DSP
- GUI enabled programming of DSP chips
- Interface with Texas Instruments boards
- Sound processing and compression with J-DSP



## J-DSP External Software Interfaces

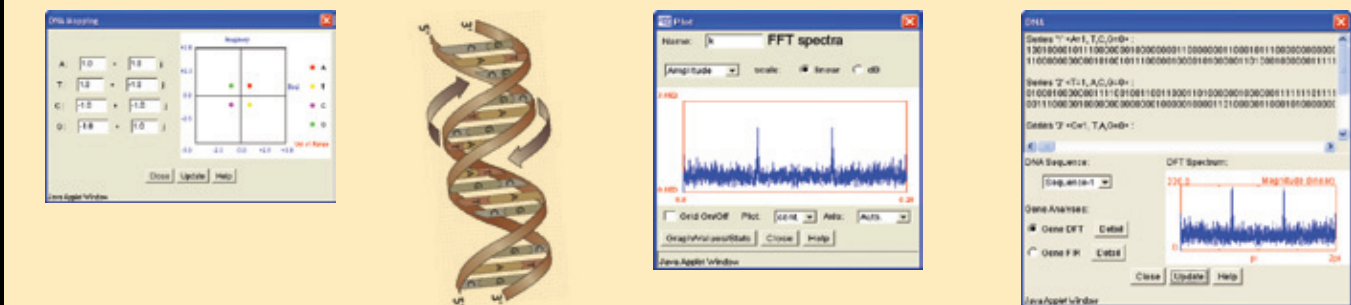
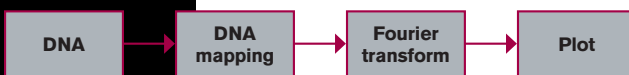
- Seamlessly embed J-DSP Simulations in Web Content using J-DSP Scripts
  - Generate MathScript™ code from J-DSP and integrate with LabVIEW
  - Export J-DSP functions as a MATLAB script



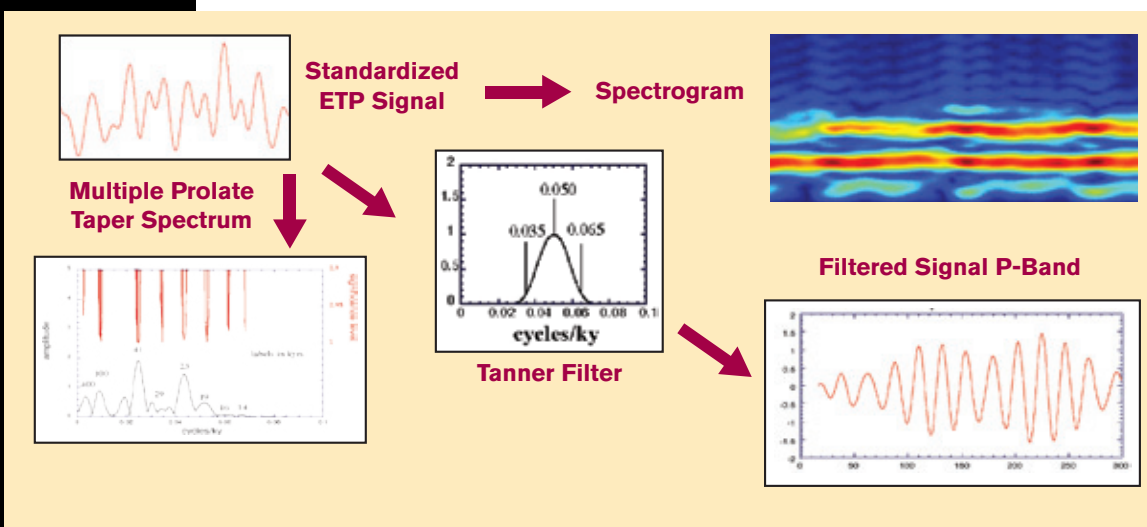
MATLAB and LabVIEW are registered trademarks of The Mathworks and National Instruments, respectively.

## Multi-Disciplinary Applications of J-DSP

- Genomics
  - Analyze the DNA sequences using numerical mapping, FFT power spectrum, and correlations.
  - Visualize the  $2\pi/3$  periodicity



## Earth-Systems



- A collaborative project between ASU, Johns Hopkins University and Purdue University.
- Functions tailored to perform analysis and visualization of earth system signals.
- Geophysicists are introduced to basic DSP concepts and get hands-on experience with analysis of Earth Systems data.

# A DSP book with J-DSP simulations and experiments

## Digital Signal Processing

An Interactive Approach

by Andreas Spanias

The book provides theoretical treatments and Java simulations of the following topics:

- Extensive review of continuous-time signals and systems concepts; Java simulation of sampling.
- Introduction to discrete-time systems and applications; J-DSP experiments on digital filters.
- DTFT, FFT, and z-transforms; pole zero diagrams and FFT spectra with Java.
- Filter design; Kaiser, Parks-McClellan, Butterworth/Chebyshev; Interactive J-DSP FIR/IIR design.
- Multirate systems, downsampling / upsampling, QMF subband coding, A/D  $\Sigma$ - $\Delta$  concepts.
- Discrete-time random signals; correlation; channel estimation. J-DSP and spectral estimation.
- Adaptive filters; LMS and RLS, Noise Cancellation. LMS convergence simulation with J-DSP.
- Quantization effects, fixed-point processing, PCM, roundoff errors, J-DSP Quantization functions.
- Speech processing algorithms. Linear prediction with Java. LPC and CELP standards.
- Audio coding, Filter banks, the MP3 algorithm; Step-by-step Java visualization of Psychoacoustics.

Computer exercises in J-DSP complement the theory and reinforce concept learning. A chapter-by-chapter comprehensive bibliography is provided with more than 100 references to additional sources of information to explore topics in greater depth.

The textbook includes all the appropriate contents and topics for undergraduate or graduate courses in digital signal processing.



The Digital Signal Processing book can be found at:  
<http://www.lulu.com/content/2581497>

ISBN 978-1-4243-2524-5

## J-DSP Assessment

The assessment results were collected from students of EEE 407 (DSP) class.

### General Assessment:

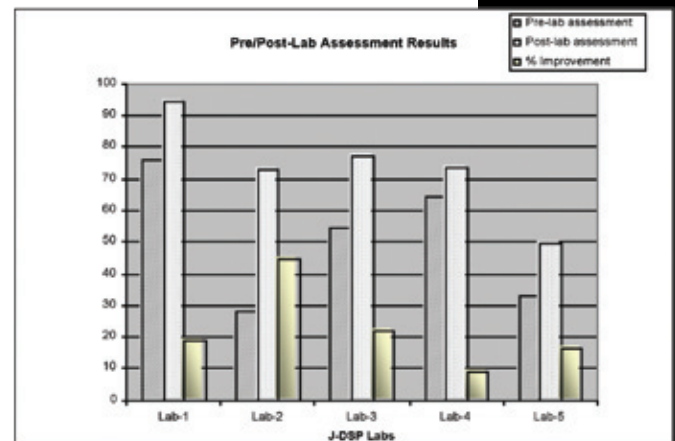
Subjective opinion about J-DSP was collected.

- 95% liked the concept of Internet-based simulations.
- 70% responded that it took them less than 30 minutes to learn how to use J-DSP.
- 85.5% are likely to consider using J-DSP to construct their own educational simulations.

### Concept-Specific Assessment:

Laboratory evaluations, both before using J-DSP (pre-lab) and after (post-lab), were carried out.

- 87% agreed that with the J-DSP filter design exercise they understood which window is suitable for sharp transitions.
- 88% understood better the signal symmetries in the FFT spectra using of J-DSP visualization.
- 91% reported that with J-DSP they understood the relation between the Pole-Zero locations and the frequency response.



**Lab – 1:** Difference Equations and Z-Transform

**Lab – 2:** Pole-Zero Plots and Frequency Responses

**Lab – 3:** FIR and IIR Filter Design

**Lab – 4:** The Fast Fourier Transform (FFT)

**Lab – 5:** Multi-rate Signal Processing and QMF Banks

<http://jdsp.asu.edu>

J-DSP in the classroom.

# NSF Multi-University Project on J-DSP Software Development

## NSF CCLI Phase 2:

**Development and Dissemination of On-Line Laboratories in Networks, Probability Theory, Signals And Systems, And Multimedia Computing**

PI : Andreas Spanias (ASU)

Co-PIs: A. Papandreou-Suppappola (ASU), C. Tepedelenioglu (ASU), J. Zhang (ASU),  
F. Bodreaux-Bartels (University of Rhode Island),  
M. Stiber (University of Washington-Bothell),  
T. Kasparis (University of Central Florida), and  
P. Loizou (UT Dallas)



**NSF award  
number 0443137**



The CCLI-EMD collaborative effort involves five universities, namely, Arizona State University (ASU), the University of Washington-Bothell (UWB), the University of Texas at Dallas (UTD), the University of Rhode Island (URI), and the University of Central Florida (UCF). This project addresses significant educational technology innovations and software extensions that enable the online software Java-DSP (J-DSP) to be used in three courses at these five universities. The Collaborative NSF EMD involves:

- Educational innovation achieved by generating a large volume of new Java software that upgrades considerably the J-DSP graphical user interface (GUI).
- A software development task that extends the mathematical and signal processing functionality of J-DSP so that it can support online computer laboratories in four courses. This task engages five faculty and several students.
- A dissemination and assessment plan that involves five universities in order to test and provide feedback on the new J-DSP GUI and all exercises and content.
- A comprehensive pilot test of a new multi-site laboratory concept that allows students in the five universities to run real-time distributed online simulations.



## NSF TUES Phase 3:

### Collaborative Research: Design and Dissemination of Multidisciplinary Digital Signal Processing Software and Content



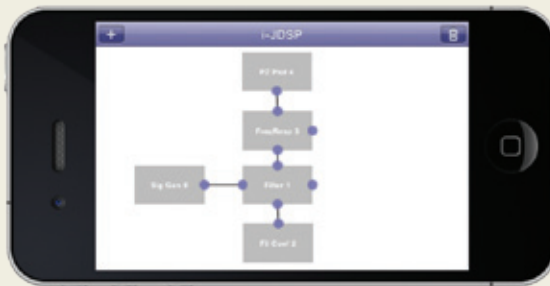
The TUES (CCLI) Phase 3 proposal builds on several products and outcomes of two previous Phase 2 CCLI EMDs and revolves around our online software technology J-DSP. This Phase 3 proposed comprehensive project expands the scope of J-DSP beyond Electrical Engineering to other fields associated with multidisciplinary applications that are central to the nation's security and economic welfare. Our first multidisciplinary activity with Johns Hopkins University and two other partners is to create a J-DSP/Earth Systems version which will be customized for earth system sciences and geology, and will also embrace issues of sustainability. The software and associated module will be used in classes at JHU. Our second multidisciplinary activity has to do with extensions of J-DSP to arts and media (with the ASU AME) providing artists with creative web-based DSP software tools and embedding and assessing J-DSP modules in AME courses. A companion activity will embed J-DSP modules in a music synthesis course at the Rose-Hulman Institute of Technology (RHIT). Our third inter-technology activity provides J-DSP and J-DSP-C modules for power engineering courses and embraces issues of renewable energy (with ASU Power Systems). A series of equally important activities with our partners target interdisciplinary and inter-technology areas including: interpreting biological signals from ion-channel sensors with J-DSP (with the Arizona Institute of Nanoelectronics), using J-DSP to expose students to the importance of signal analysis in sensing and genomics (with the ASU SenSIP; <http://sensip.asu.edu>), embedding J-DSP in FPGA systems courses (with UNM), embedding J-DSP in computing and programming applications (UWB), and embedding J-DSP in DSP courses (with PVAMU).

# An Interactive Signal Processing Tool for iOS and Android devices



The ASU i-JDSP app has been selected by the NEEDS panel as the **Premier Award winner for 2012**. The Premier Award is sponsored by John Wiley & Sons, Microsoft Research, the MathWorks, and TechSmith.

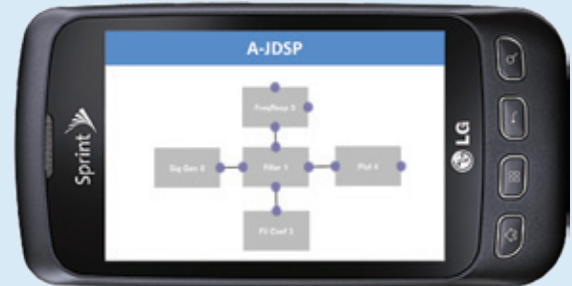
## i-JDSP



i-JDSP is an interactive iPhone/iPad signal processing tool based on JDSP. It is implemented in Objective-C and C as a native Cocoa Touch application that can be run on any iOS device. It provides a very compelling multi-touch programming experience. All simulations can be visually established by forming interactive block diagrams through multi-touch and drag-and-drop.

**iJDSP is now available for download in the iTunes App store for free!**

## A-JDSP



A-JDSP is an interactive Android application based on JDSP. It can run on Android phones and tablets. Interfaces for education and research are being designed. An interface with hardware will be used for monitoring and control of a sensor network. All system and network simulations can be visually established through a drag-and-drop interface.

**On Andriod App store early 2013.**

### Key Features

- Graphical programming experience.
- Easy to use multi-touch and drag-and-drop.
- Access through online app store.
- Small footprint, efficiency and scalability.
- Wireless interface to sensor network hardware.
- Interface to real-time DSP board.
- z transform and pole-zero dashboard.
- Functions for outreach.
- Runs on iPhone, iPad and iPod touch.
- Coming soon health monitoring functions.

### Planned Functions

- Signal Generator
- Digital Filters
- Filter Design
- Frequency Response
- Fast Fourier Transform (FFT)
- Magnitude and Phase Plots
- Pole-zero Plot
- Audio Spectrogram
- Speech and Audio Coding
- Demos

i-JDSP and A-JDSP are supported in part by NSF award 0817596, the SenSIP center and Sprint Communications.



## Publications

- A. Clausen, A. Spanias, A. Xavier, M. Tampi, "A Java signal analysis tool for signal processing experiments," Proc. IEEE ICASSP, vol.3, no. pp.1849-1852 vol.3, Seattle, May 1998.
- A. Spanias, et al, "Development of a Web-based Signal and Speech Processing Laboratory for Distance Learning," ASEE Computers in Education Journal, pp. 21-26, Vol. X, No.2, April-June 2000.
- T. Thrasyvoulou, K. Tsakalis, A. Spanias, "J-DSP-C, a control systems simulation environment: labs and assessment," Proc. IEEE FIE 2003, pp. T4E\_11- T4E\_16, Denver, Nov. 2003.
- A. Spanias, T. Thrasyvoulou, Yu Song, C. Panayiotou, "Using J-DSP to introduce communications and multimedia technologies to high schools," Proc. IEEE FIE 2003, vol. 2, pp. F3A\_22- F3A\_27, Denver, Nov. 2003.
- A. Spanias, V. Atti, T. Thrasyvoulou, M. Yasin, M. Zaman, T. Duman, L. Karam, A. Papandreou, K. Tsakalis, "On-line laboratories for speech and image processing and for communication systems using J-DSP," Proc. IEEE DSP and SPE Workshop, pp. 174- 179, Pine Mountain, Oct. 2002.
- A. Spanias, C. Panayiotou, T. Thrasyvoulou, V. Atti, "Java-DSP Interface with MATLAB and its Use in Engineering Education," Proc. of ASEE-2004 Conference, Salt Lake City, Utah, June 2004.
- A. Spanias, et al, "Teaching Genomics and Bioinformatics to Undergraduates using J-DSP," Proc. of ASEE-2004 Conference, Salt Lake City, June 2004.
- Yu Song, A. Spanias, V. Atti, V. Berisha, "Interactive Java modules for the MPEG-1 psychoacoustic model [audio coding teaching applications]," Proc. IEEE ICASSP, vol.5, pp. v/581 - v/584, Vol. 5, Philadelphia, March 2005.
- A. Spanias, V. Atti, "The JAVA-DSP (J-DSP) PROJECT – From the Prototype to the Full Implementation and Dissemination," Proc. of 2005 ASEE -2005 Conference, Portland, June 12-15, 2005.
- A. Spanias, R. Chilumula, C. Huang, "Collaborative Signals and Systems Laboratories at ASU, UWB, UCF, UTD, and URI," Proc. IEEE FIE 2006, San Diego, October 2006.
- A. Spanias, V. Berisha, H. Kwon, C. Huang, A. Natarajan, R. Ferzli, "Using the Java-DSP Real-Time Hardware Interface In Undergraduate Classes," Session M4D, Proc. IEEE FIE-2006, San Diego, October 2006.
- A. Spanias, Jayaraman J. Thiagarajan, Karthikeyan Natesan Ramamurthy, "Using the J-DSP Online Export Capabilities to Perform Undergraduate DSP Labs with LabVIEW," Proc. ASEE-2007, June 2007.
- Spanias, A.; Hinnov, L.; Stiber, M.; Akujuobi, C.; Pattichis, M.; Pattichis, C.; Doering, E.; Ramamurthy, K.; Mehta, S., "The Java-DSP Phase 3 project: An interdisciplinary multiuniversity effort," Proc. of ASEE-2009 Conference, Austin, Texas, June 2009.
- Ramamurthy, K.; Spanias, A.; Hinnov, L.; Akujuobi, C.; Stiber, M.; Pattichis, M.; Doering, E.; Pattichis, C.; Thornburg, H.; Papandreou-Suppappola, A.; Spanias, P.; Ayyanar, R.; Campana, E.; Haag, S., "WIP - Collaborative multidisciplinary J-DSP software project," IEEE FIE '09. 1-2, Oct. 2009.
- Mehta, S.; Thiagarajan, J.J.; Spanias, P.; Ramamurthy, K.; Santucci, R.; Spanias, A.; Haag, S.; Banavar, M., "An interactive learning environment for DSP," Proc. of ASEE-2010 Conference, Louisville, Kentucky, June 2010.
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- Shah, M.; Wichern, G.; Spanias, A.; Thornburg, H., "Audio content-based feature extraction algorithms using J-DSP for arts, media and engineering courses," IEEE FIE 2010, Oct. 27-30, 2010.
- Mehta, S.M.; Spanias, A.; Thiagarajan, J.J., "Work in progress — An interactive web-based quiz that uses the java-DSP editor to enhance student learning experience," IEEE FIE 2010, pp.T2G-1- T2G-2, Oct. 27-30, 2010.
- Huang, C.; Thiagarajan, J. J.; Spanias, A.; Pattichis, C., "A Java-DSP interface for analysis of the MP3 algorithm," Proc. of the IEEE DSP/SPE Workshop, pp.168-173, 4-7 Jan. 2011.
- Ramamurthy, K. N.; Spanias, A.; Hinnov, A., "J-DSP/ESE laboratories for analyzing climate change," Proc. of ASEE-2011 Conference, Vancouver, June 2011.
- Thiagarajan, J. J.; Spanias, A.; Ayyanar, R. , "Designing online laboratories for power electronics courses using J-DSP software," Proc. of ASEE-2011 Conference, Vancouver, June 2011.
- Santucci, B.; Spanias, A., "Use of Java-DSP to Demonstrate Power Amplifier Linearization Techniques," Proc. of ASEE-2011 Conference, Vancouver, BC, Canada, June 2011.
- Liu, J.; Thiagarajan, J. J.; Spanias, A.; Ramamurthy, K. N.; Hu, S.; Banavar, M. K. , "iPhone/iPad-Based Interactive Laboratory for Signal Processing in Mobile Devices," Proc. of ASEE-2011 Conference, Vancouver, June 2011.
- Liu, J.; Spanias, A.; Banavar, M. K.; Thiagarajan, J. J.; Ramamurthy, K. N.; Hu, S.; Xue, S., Work in Progress - Interactive signal processing labs and simulations on iOS devices," IEEE FIE 2011, South Dakota, October 2011.
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- Ranganath S., Thiagarajan J., Ramamurthy K., Hu S., Banavar M., Spanias A., "WIP: Signal Analysis Laboratories using Android Devices," Proc. IEEE FIE 2012, Seattle, October 2012.

## J-DSP

Andreas Spanias is the director of the J-DSP GUI design and software development team and the PI on the three NSF projects that supported portions of this project. Several ASU graduate students helped with the development of J-DSP functions including V. Atti, C. Panayiotou, T. Thrasyvoulou, Y. Song, A. Constantinou, A. Clausen, H. Krishnamoorthi, C. Huang, J. Thiagarajan, K. Ramamurthy, A. Natarajan, M. Zaman, K. Ahmed, F. Bizuneh, T. Painter, H. Kwon, M. Banavar, S. Misra, V. Berisha, R. Chilumula, M. Tampi, M. Shah, S. Mehta, G. Stylianou, S. Ranganath, X. Zhang, S. Zhang, D. Rajan, B. Santucci, P. Sattigeri, J. Liu, S. Hu, G. Kalyanasundaram.. Certain specialized functions were designed by consulting with several colleagues including: Antonia Papandreou-Suppappola, Michael Stiber, Tolga Duman, Linda Hinnov, Lina Karam, and Kostas Tsakalis. J-DSP concept by A. Spanias.

<http://jdsp.asu.edu>



J-DSP development team.

**J-DSP**  
 Signal  
 Remote Sensing  
 Simulations  
 Interface  
 Processing  
 Object-Oriented  
 Education  
 Programming  
 Functions  
 MP3  
 Frequency  
 Visualization  
 Communications  
**JAVA**  
 Innovation  
 Multidisciplinary  
 Visualization  
**System**  
 Mapping  
**Spectrum**  
 Monitoring  
 Tracking  
 Localization  
 Implementation  
 Reverberation  
**GUI**  
 On-line  
 Research  
 Algorithms  
 Generators

## Become a test site for J-DSP

- Host a mirror site at your university.
- Include J-DSP in your simulations and class notes.
- Use J-DSP in research and health monitoring.
- Collaborate with ASU and embed J-DSP in your dissemination plans.
- Use the new i-JDSP and A-JDSP with iPhone/iPad and Android tablets.
- Use i-JDSP for outreach.



## Contact Information

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J-DSP was sponsored in part by the National Science Foundation (NSF) EMD, TUES and CRCD awards 0817596, 0443137 and 0417604. Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect those of the National Science Foundation.

## i-JDSP for Outreach



## J-DSP Workshops

- November 2012, DSP Tools on Android devices, ASU Main Campus, Tempe, AZ
- July 23, 2012, University of Cyprus, Cyprus.
- March 9, 2012, Signal Analysis on the iPhone and iPad, ASU Main Campus, Tempe, AZ
- January 27, 2012, J-DSP/ESE Tools for Earth Systems and Sustainability, ASU Main Campus, Tempe, AZ
- January 4, 2011, IEEE DSP-SPE Workshop, Sedona AZ
- March 14, 2010, Joint Section Meeting, Geological Society of America (GSA), Baltimore, Maryland
- October 18, 2009, IEEE Frontiers in Education (FIE) Conference, San Antonio, Texas
- June 24, 2009, Arizona State University main campus, Tempe, Arizona
- Workshops will be scheduled in Houston, Indianapolis, London, New York city, Orlando, Cyprus.

## Awards

October 2012: The ASU iJDSP app for the iPhone/iPad was selected by the NEEDS panel as the Premier Award winner for 2012. The Premier Award is sponsored by John Wiley & Sons, Microsoft Research, the MathWorks, and TechSmith.

Feb 2007: J-DSP Team Award: For developing the outstanding non-commercial software J-DSP for Education and Research, IEEE Phoenix section.

Oct 2003: J-DSP voted as one of the top three learning resources for 2003 by the National Engineering Education Delivery System (NEEDS).

<http://jdsp.asu.edu>

