

AC 2009-1269: THE JAVA-DSP PHASE 3 PROJECT: AN INTERDISCIPLINARY MULTIUNIVERSITY EFFORT

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THE JAVA-DSP PHASE 3 PROJECT; AN INTERDISCIPLINARY MULTI-UNIVERSITY EFFORT

1. Introduction

Java-Digital Signal Processing (J-DSP) is a web-based, platform-independent, visual programming environment that enables users to perform online signal processing calculations and simulations¹. It is based on an object-oriented programming environment that allows students and practitioners to run simulations over the Internet. Simulations can be performed in the intuitive graphical interface of J-DSP by placing and connecting “blocks” to establish signal and data flow. Students can also visualize the results interactively in the simulation environment. Original J-DSP functionality included algorithms for signal processing², imaging³, controls⁴, time-frequency analysis⁵ and communications applications⁶.

This paper presents our plans in the NSF CCLI Phase 3 project which are aimed at developing, disseminating and assessing several new J-DSP capabilities. By engaging a total of seven universities in the development and assessment of software and course content, we extend the utility of J-DSP to several disciplines including Electrical Engineering, Earth Sciences, Biomedical Engineering, Power Engineering, and Arts and Media. The key outcomes of the CCLI phase 2 project included a) upgrades to the J-DSP GUI, b) extensions in the signal processing functionality of J-DSP, c) on-line laboratory exercise development, and d) dissemination and assessment and a pilot test of a new multi-site laboratory concept that allows students in the five universities to run real time distributed on-line simulations. Results of the Phase 2 project have been published mainly for Electrical Engineering courses and applications¹⁻⁶. In addition, a book that uses J-DSP for online laboratory exercises has been published⁷ and is used in two courses at Arizona State University. The phase 3 multidisciplinary NSF CCLI project is a collaborative project involving Arizona State University (ASU), Johns Hopkins University (JHU), University of Washington Bothell (UWB), and Prairie View A&M University (PVAMU). In addition to these four institutions that are a part of the formal NSF research collaborative structure, the project also involves sponsored partnerships with Rose-Hulman Institute of Technology (RHIT), University of New Mexico (UNM), and University of Cyprus (UCY). Other partnerships through the collaborating institutions have also been organized with the University of Texas at Austin and the University of Padova.



Figure 1: Multidisciplinary and multiuniversity collaborative phase 3 project.

2. Multidisciplinary Extensions to J-DSP

Several multidisciplinary extensions to J-DSP are being developed for the phase 3 project and they are discussed in detail in this section. By involving several universities, the project aims to expand the scope and applicability of J-DSP beyond Electrical engineering. The multidisciplinary collaboration with Johns Hopkins University is aimed at creating J-DSP/Earth Systems Edition which is a customized version of J-DSP for Earth science and geology systems⁸. In the Arts, Media and Engineering (AME) program at ASU, J-DSP will be extended to provide artists with creative web-based DSP software tools. In a collaborative activity with RHIT, J-DSP modules will be embedded in a music synthesis course. Other important interdisciplinary activities include the use of J-DSP in power engineering courses at ASU, interfacing ion-channel sensors with J-DSP for interpreting biological signals, exposing the students to importance of signal analysis in sensing and genomics in collaboration with the ASU SenSIP center, embedding J-DSP in FPGA systems courses in collaboration with UNM, embedding J-DSP in

computing and programming applications at UWB and creating educational modules using J-DSP for DSP courses at PVAMU. Detailed description of the key modules of the phase 3 project is given below.

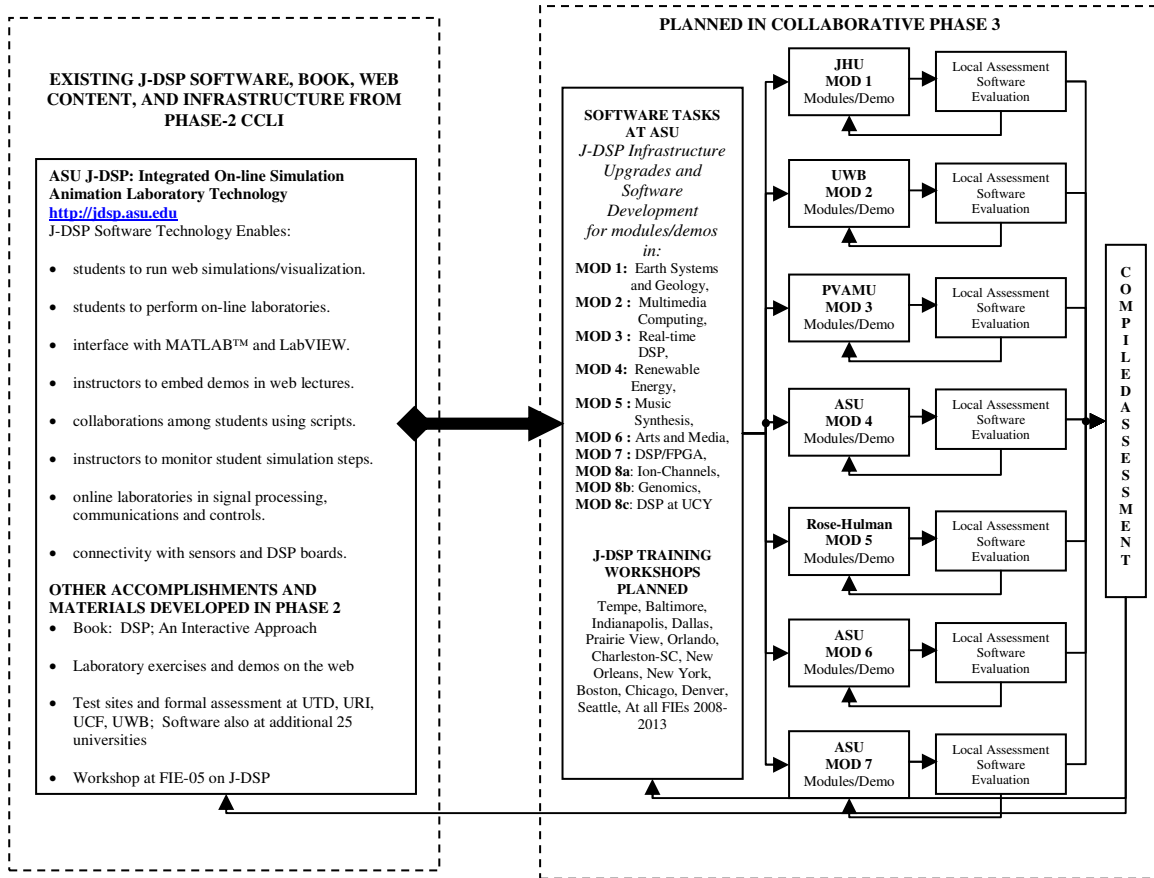


Figure 2: Phase 2 accomplishments and phase 3 goals.

2.1 J-DSP in Earth Systems

A version of J-DSP specifically suited to Earth systems and geological time series analysis is being developed in collaboration with JHU. The new version of J-DSP known as J-DSP/Earth Systems Edition (J-DSP/ESE) includes functions for generating the Earth systems data, performing depth to time transformation, interpolation/re-sampling, filter design, windowing, fast Fourier transforms (FFT/IFFT), and time-frequency analysis⁸. A screenshot of the J-DSP/ESE block diagram is shown in Figure 3, which shows the customized functions developed for Earth systems signals. Assessment of J-DSP/ESE will be conducted in Earth systems class in JHU to provide students with hands-on experience with analysis, processing and visualization of

Earth systems signals and in DSP class at ASU in order to expose the students to the interdisciplinary areas where DSP techniques can be applied.

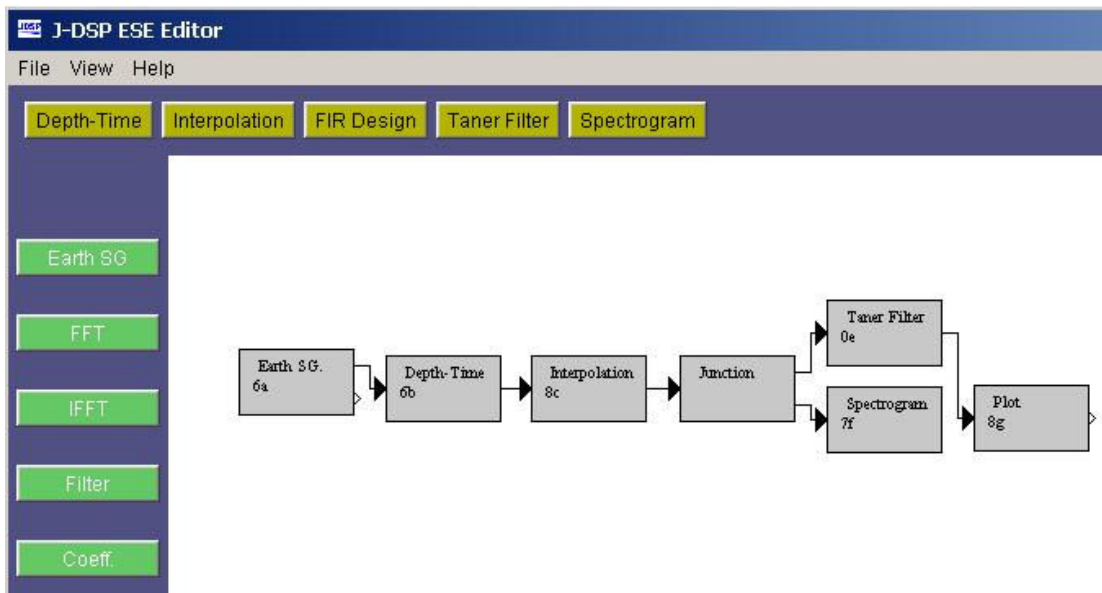


Figure 3: Basic J-DSP/ESE block diagram.

2.2 J-DSP for Multimedia Computing

The proposed extensions of Java-DSP for multimedia computing course in UWB will focus on connecting students' knowledge of data-structures, algorithms, system analysis and design. For this purpose, a Java-DSP lab will be introduced in the course to make students understand the data structures for digital signals, comprehend the mathematical foundations with minimal prerequisites, understand the operation of multimedia computing devices and see how multimedia computing fits as a software component within larger systems. J-DSP will be adapted as a multimedia computing workbench which will allow the students to build systems and understand how the systems are programmed.

2.3 J-DSP for Music Synthesis

The powerful functions for speech, audio processing, real-time spectrum visualization and modulation of J-DSP will be leveraged in the Electronic Music Synthesis course at RHIT in order to illustrate several key concepts to the students. The relationship between parameter

choices and the corresponding spectra for different Amplitude Modulation (AM) and Frequency Modulation (FM) techniques will be studied using J-DSP. The Linear Predictive Coding (LPC) tools and vocoder demo will also be incorporated in the course and the assessment conducted in each course offering will be used as feedback to evaluate and improve the material.

2.4 J-DSP for Arts and Media

The AME program⁹ at ASU is highly transdisciplinary bringing together faculty from diverse areas such as computer science, electrical engineering, industrial design, music, psychology, and visual art. The courses offered in AME are accessible to any of the component disciplines. Courses such as Computational Principles for Media Arts and Sound Sensing and Analysis for Interactive Environments will use J-DSP for educating the students on some aspects of time series analysis. A separate module for arts and media will be developed and exercises and assessments will be created for use in these courses.

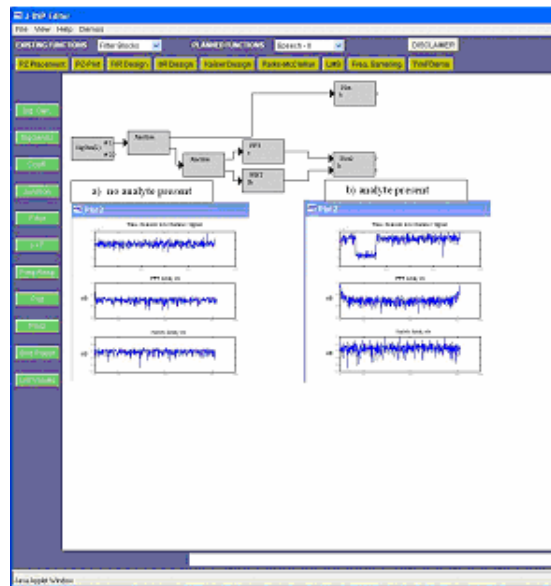


Figure 4: J-DSP simulation of ion-channel currents.

2.5 J-DSP for Ion-Channel Sensing

The collaborative effort for developing J-DSP functions to interpret biological signals such as ion-channel data is being carried out with ASU Institute of Nanoelectronics. Functions have been developed in J-DSP and ion-channel signal processing¹⁰ is simulated as shown in Figure 4.

Students can visualize the binding phenomena in ion channels and how they manifest in time and transform domains. The module will be injected in signal processing classes and it will also be introduced in chemistry and biology undergraduate courses as well as computer science classes.

2.6 Other Extensions Planned

J-DSP will be extended to renewable energy areas at ASU where a solid working knowledge of DSP concepts is essential for power electronics professionals. J-DSP, and in particular its controls version J-DSP-C, will be extended to create a module that can help understanding the DSP principles, analysis and design of controllers for power electronic applications. At UNM, J-DSP will be used to introduce the use of digital filters and it will be integrated with the FPGA implementation of digital filters. In the Advanced Topics in Image Processing course, 2D filters will be designed and simulated with J-DSP and integrated with the FPGA lab.

Several functions have been developed in J-DSP for displaying DNA data¹¹. As a part of this project, a number of functions for applying signal analysis tools to J-DSP will be developed. Explaining the basics of nucleotide sequences and its relation to signal analysis will form a major part of the J-DSP module and it will be injected into the signal processing courses at ASU. Apart from these, as a part of international collaboration, J-DSP will be injected in signal and image processing courses and assessments will be performed at UCY.

3. Labs and Assessments

Each module will carry its own assessment and laboratories. This is because of the multidisciplinary nature of the extensions provided to J-DSP which necessitates a separate instrument of evaluation for each assessment. The major challenge is to move away from the traditional formats of teaching to an active learning approach that stimulates critical thinking and creates a significant learning experience. The planned J-DSP labs will encourage the students to understand the theory and principles both independently and collaboratively.

The common criteria for evaluation of the modules will be in terms of their overall impact in learning and achievement of goals and the effects of each module component. There is a set of on-line assessment instruments already present that were developed for the previous J-DSP labs

in the DSP class at ASU. The assessment tools will be adapted, revised and improved to measure student learning.

4. Conclusion

The NSF CCLI phase 3 J-DSP project detailed in this paper extends significantly the phase 2 accomplishments by incorporating multidisciplinary extensions, innovative assessment techniques, and extensive worldwide dissemination. Several workshops are planned nationwide with all partner universities. The project embraces multidisciplinary areas that use signal and data analysis techniques and through the development of specialized modules it introduces several DSP tools and concepts in diverse areas and communities. In terms of education, our activities will help students further develop a positive attitude towards learning several STEM related topics through the use of this highly intuitive and interactive environment.

5. References

1. Spanias, A., and Atti, V., "Interactive online undergraduate laboratories using J-DSP," *IEEE Transactions on Education*, vol. 48, no. 4, pp. 735- 749, November 2005.
2. Spanias, A., Atti, V., Ko, Y., Thrassyvoulou, T., Yasin, M., Zaman, M., Duman, T., Karam, L., Papandreou, A., and Tsakalis, K., "On-Line Laboratories for Speech and Image Processing and for Communication Systems Using J-DSP," *10th IEEE DSP Workshop*, Pine Mountain, GA, October 2002.
3. Yasin, M., Karam, L.J., and Spanias, A., "On-line laboratories for image and two-dimensional signal processing," *33rd ASEE/IEEE FIE Conference*, Boulder, November 2003.
4. Thrassyvoulou T., Tsakalis K., and Spanias, A., "J-DSP-C, A Control Systems Simulation Environment for Distance Learning: Labs and Assessment," *33rd ASEE/IEEE FIE Conference*, Boulder, November 2003.
5. Zaman, M., Papandreou-Suppappola, A., and Spanias, A., "Advanced concepts in time-frequency signal processing made simple," *33rd ASEE/IEEE FIE Conference*, Boulder, November 2003.
6. Ko, Y., Duman, T., and Spanias, A., "J-DSP for communications," *33rd ASEE/IEEE FIE Conference*, Boulder, November 2003.
7. Spanias, A., "DSP –An Interactive Approach," Lulu Press, 2007.
8. Ramamurthy, K., Spanias, A., Hinnov, L., and Ogg, J., "On the use of J-DSP in Earth systems," *Proceedings of ASEE Annual Conference and Exposition*, Pittsburgh, PA, June 2008.

9. Rikakis, T., Spanias, A., Sundaram, H., and He, J., "An Arts, Sciences and Engineering Education and Research Initiative for Experiential Media," 36th *IEEE FIE Conference*, San Deigo, CA, October 2006.
10. Spanias, A., Knee, P., Kwon, H., Ramamurthy, K.N., Thiagarajan J.J., and Spanias, P., "Work in progress - Java simulations of DSP algorithms for ion-channel sensors," 38th *IEEE FIE Conference*, New York, NY, October 2008.
11. Spanias, A., Chakravarthy, N., Song, Y., and Iasemidis, L.A., "Teaching Genomics and Bioinformatics to Undergraduates using J-DSP," *Proceedings. of ASEE Conference*, Salt Lake City, Utah, June 2004.