CONNEXIONS AND THE SPEN FELLOWS PROGRAM

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ABSTRACT

Texas Instruments (TI) has created the Signal Processing Education Network (SPEN) Fellows program to help identify and fill content gaps within the signal processing content library hosted on the Connexions ecosystem. This paper will overview Connexions, SPEN, the SPEN Fellows program, and review this year's SPEN Fellows project involving Connexions content creation involving real-time DSP (RT-DSP).

1. INTRODUCTION

It is well established that "Connexions is a dynamic digital educational ecosystem consisting of an educational content repository and a content management system optimized for the delivery of educational content. Connexions is one of the most popular open education sites in the world. Its more than 17,000 learning objects or modules in its repository and over 1000 collections (textbooks, journal articles, etc.) are used by over 2 million people per month. Its content services the educational needs of learners of all ages, in nearly every discipline, from math and science to history and English to psychology and sociology. Connexions delivers content for free over the Internet for schools, educators, students, and parents to access 24/7/365. Materials are easily downloadable to almost any mobile device for use anywhere, anytime. Schools can also order low cost hard copy sets of the materials (textbooks) [1]." Applications of Connexions within the signal processing community is also well established [2–4].

"The Signal Processing Education Network (SPEN) community is working to develop a comprehensive signal processing curriculum that includes textbook and lecture materials, interactive simulations, and problems and solutions. The team is currently creating an inventory of the extant core of signal processing content in Connexions. The next step is to analyze the existing content, identify gaps, and finally develop textbooks that are equivalent in quality to the most popular signal processing texts currently available. Using Connexions, this curriculum will be free for anyone to use and open so that anyone can adapt it for their purposes [5]."

"SPEN fellows are exemplary members of the SP community, who have been nominated by peers and selected by the Principal Investigators, to provide leadership and fulfill specific duties of a SPEN Fellow. A SPEN fellow is chosen based on their expertise in one or more of the topics above. After they are nominated and subsequently chosen by the panel of SPEN Principle Investigators, they will be informed of their selection. Should they choose to accept the position, they will be awarded an honorarium and charged with the responsibility of architecting a high quality digital textbook in Connexions. In more detail, architecting refers to the following task [5]:

1. Outlining an appropriate and comprehensive approach to teaching the topic.
2. Identifying existing materials in Connexions that fit into the outline.
3. Identifying gaps and inadequacies in the existing materials.
4. Suggest laboratory tools and procedures that complement the theoretical course.
5. Build out the collection in Connexions as much as possible."

2. THIS YEAR'S PROJECT

During the Fall 2011 SPEN Workshop, that was held at the Georgia Institute of Technology, in Atlanta, Georgia, USA, Texas Instruments (TI) announced the inaugural SPEN Fellow. As outlined above, the SPEN Fellow was tasked with identifying gaps within the currently available signal processing content in the Connexions ecosystem.

This year's project involved the insertion of real-time digital signal processing (RT-DSP) examples and demonstrations into Connexions. This was accomplished by adding Connexions content based upon the authors' freely available winDSK6 and winDSK8 programs. Although they are very similar, winDSK6 is used in conjunction with the C6713 DSP starter kit (DSK) while winDSK8 is used with the OMAP-L138 eXperimenter Kit.

While the C6713 DSK is still available for real-time DSP, the recently introduced Zoom™ OMAP-L138 eXperimenter Kit from Logic Product Development Company (LogicPD) [6], featuring Texas Instruments' dual core system on a chip (SoC) (ARM9 and a C6748 VLIW DSP), provides a much more capable DSP development system to both university and industry engineers [7]. Compared to the still-available Texas Instruments (TI) TMS320C6713 digital signal processing starter kit (DSK), this new DSP board may lower the cost of real-time system implementation. Both boards are discussed and fully supported by the authors' recently updated text and accompanying software [8].

When comparing the new OMAP-based board to the C6713 DSK, quite a few changes are evident. Depending upon the user and the intended application, these may be considered improvements or unnecessary complications. The OMAP-L138 SoC includes a multi-core processor that contains both a C6748 VLIW digital signal processor and an ARM926EJ-S RISC general purpose processor, both running at 300 MHz. In the experimenter kit configuration from LogicPD, the processor has 64 MB of DDR RAM and a wide variety of I/O capabilities. The C6713 DSK, on the other hand, uses a single-core TMS320C6713 VLIW digital signal processor running at 225 MHz, with 16 MB of RAM. Since both DSPs are from the TI C67x series, most of the code directly associated with performing signal processing algorithms may remain the same. However, the shift to an OMAP has drastically changed the required host computer-to-board communication technique.

In order to achieve the necessary communication rates to allow for non-trivial real-time DSP operations, the older TI TMS320C6713 DSK required a host port interface (HPI) daughterboard. The HPI daughterboard was developed mainly for educators, and made possible high-speed data transfer, both to and from the host computer, bypassing the JTAG (IEEE Std 1149.1) debugger interface [9, 10]. This was necessary since this debugger interface is extremely limited in bandwidth, required that the TI Code Composer Studio (CCS) software tools also be available on the host computer, and routinely required the DSP to be halted to accomplish data transfer. Using this HPI daughterboard allowed for continued use of the existing suite of winDSK6 demonstration software, as well as a number of other custom, but freely available, software tools. These tools were developed for educators as valuable real-time teaching and classroom demonstration resources [11–14].

For many years, the authors have advocated the systematic use of proven DSP teaching methodologies, coupled with interactive "hands-on" hardware and software solutions, that have helped motivate students and faculty to implement DSP-based systems in real-time [14–21]. This approach includes the availability and use of the appropriate version of winDSK. While the suitability of the older C6713 DSK for this approach is severely hindered without the HPI board, the OMAP-L138 board also suffers from some significant "out-of-the-box" interface limitations. Unfortunately, there is no easy connection to the HPI port on the OMAP-L138 board, and the daughterboard solution that was used for the C6713 DSK was not practical for this new DSP board.

3. OMAP-L138 COMMUNICATIONS

As it comes out of the box, the LogicPD Zoom OMAP-L138 eXperimenter Kit board has a wide variety of input and output connections, but many of these connections are not well suited to our time-tested DSP educational methods. In addition to a number of specialized connections, the LogicPD Zoom OMAP-L138 eXperimenter Kit has two USB mini-B's, an RJ-45 (Ethernet), and an RS-232 (serial port) connector. One of the USB mini-B's is connected to a dual UART and it is intended for debugging. The other USB mini-B is connected directly to the OMAP-L138 and to communicate using this port would require an installed driver stack. We believe LogicPD intended that this would be accomplished by loading all, or some portion of, a LINUX system that would run on the ARM9 core. While we ultimately hope to use either the RJ-45 (ethernet) or a USB connector for host computer communications in a future implementation of winDSK, the RS-232 port represented a more readily available, albeit temporary, solution to establishing reliable high-speed host to real-time target communications that would allow the full suite of winDSK programs to run.

To prepare the OMAP board, the user loads winDSK8 code into the LogicPD Zoom OMAP-L138 eXperimenter Kit's flash memory utilizing the RS-232 port and a free flash programming utility. This needs to be done only once (unless the user needs to reprogram the flash memory for some other purpose later). Power-on program execution is determined by the board's DIP switches. With the DIP switches in the correct position, the ARM9 processor will load the winDSK8 code from the flash memory upon power up, and the ARM9 then takes control of the C6748 DSP core with communication to the host computer accomplished via the RS-232 port. In this way, the ARM9 is acting in much the same way that the host port interface (HPI) board acted on the older C6713 DSK, but accomplishes these communication functions locally via the RS-232 port and the SoC without the need for an additional daughtercard.

Many newer computers, particularly laptops, no longer come with serial ports (RS-232), since the ubiquitous USB interface has taken over many of the user's I/O needs. If the particular host computer to be used with the OMAP board and winDSK8 does not have a serial port, an inexpensive USB-to-serial adapter works quite well. We have achieved transfer rates of over 900 kBaud using these adapters (but be aware that some older USB-to-serial adapters do not support such high data transfer rates). We anticipate that a forthcoming modification to the eXperimenter Kit by LogicPD will allow a more direct connection to the OMAP-L138 UART, bypassing the RS-232 line drivers.

When using winDSK6 with a C6713 DSK, clicking on a button in the graphical user interface (GUI) on the host computer initiated a download of the appropriate code from the host to the DSK, and started the code running on the DSK.

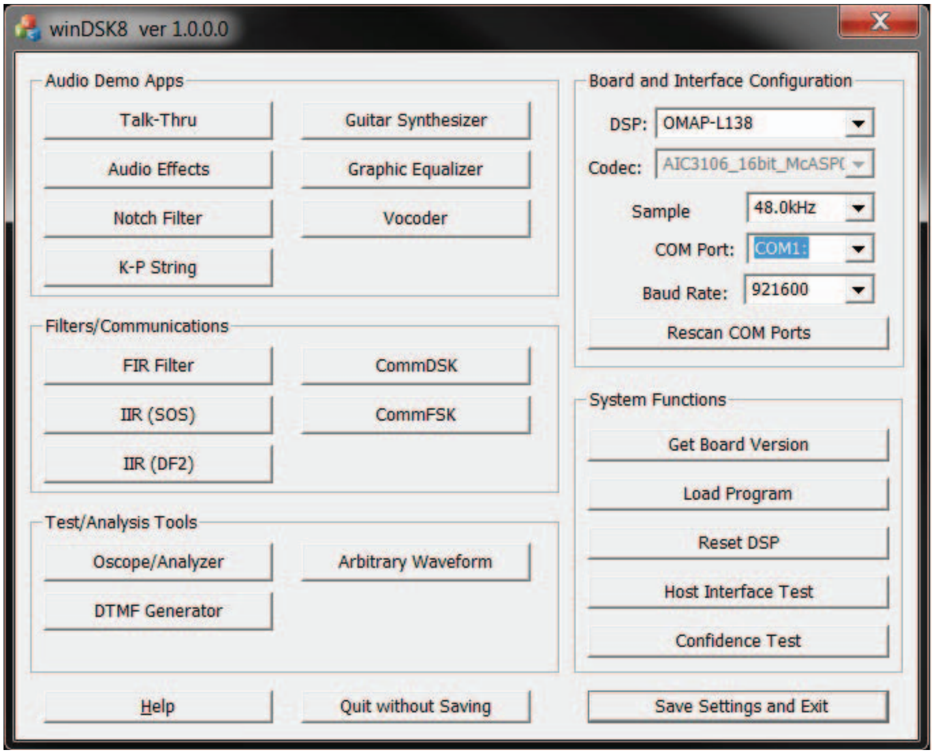

Fig. 1. The new winDSK8 user interface.

When using winDSK8 with an OMAP-L138 eXperimenter Kit, clicking on a button in the GUI on the host computer sends a short message to the ARM9 core on the OMAP board telling it to load the appropriate code from the on-board flash memory into the C6748 core and start it running. From the user's perspective, the primary difference between running winDSK6 on the C6713 DSK and running winDSK8 on the OMAP-L138 is that the former used a USB connection to the HPI daughtercard, while the latter uses a serial RS-232 connection to the main OMAP-L138 board. While the user experience is very similar, we have taken the opportunity of this update to enhance the winDSK8 program when compared to the previous version.

4. WINDSK8

The new interface for winDSK8 is shown in Figure 1. While a number of functions have been enhanced, the vast majority of the new look is associated with the regrouping of similar functions into sections labeled "Audio Demo Apps," "Filters/Communications," and "Test/Analysis Tools." New programs include the "Vocoder" and "commFSK." Both the regrouping of programs and the inclusion of the two new programs actually took place in one of the latest versions of winDSK6. Additionally, in winDSK8, the "Board and Interface Configuration" section was updated to support the OMAP-L138, allow for a master setting of the system's sample frequency, and for control of the communication parameters associated with the board's serial (RS-232) port. The data transfer rates using the RS-232 port exceeds the data transfer rates associated with the C6713/HPI-based system. We restate here that since many new computers no longer include a serial (RS-232) port, a USB-to-RS-232 converter cable/system may be required.

5. CONCLUSIONS

Texas Instruments (TI) has created the Signal Processing Education Network (SPEN) Fellows program to help identify and fill content gaps within the signal processing content library hosted on the Connexions ecosystem. This program has significantly contributed to the creation of Connexions content supporting the introduction of RT-DSP concepts, examples, and demonstrations into the signal processing classroom. This content is based upon the winDSK8 program which is freely available for educational, non-profit use. We invite user suggestions for improvement in this and related tools (see [10]). Interested parties are also invited to contact the authors via e-mail.

The authors recognize that advances in DSP hardware come quickly, and in response have established a support site for real-time DSP [22]. This site does not compete in any way with the Connexions site [1], but will be used to provide updates for the existing boards (such as the C6713 DSK and the OMAP-L138 eXperimenter Kit), related tools for new DSP boards that maybe introduced, and other support material for the associated text [8].

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