International Symposium on Signal Processing and its Applications, ISSPA, Gold Coast, Australia, 25-30 August, 1996. Organized by the Signal Processing Research Centre, QUT, Brisbane, Australia.

AN INTEGRATED TEACHING TECHNIQUE FOR MANAGEMENT OF DIGITAL SIGNAL PROCCESSING EDUCATION

Girija Chetty

Gippsland School of Engineering
Monash University, Churchill Victoria, 3842
e-mail: Girija.Chetty@eng.monash.edu.au

ABSTRACT

Digital Signal Processing (DSP) has become one of key enabling technologies for telecommunication, condition monitoring, multimedia computing and other areas requiring information processing. Until recently, DSP was taught only at senior graduate level. With the rapid growth of applications of DSP in the industry, it has become necessary to introduce these concepts to undergraduates. This paper presents the details of the work done in the development of an integrated teaching methodology for delivering digital signal processing course for on-campus and distance education engineering students at Gippsland campus of Monash University, Australia.

1. INTRODUCTION

Significant technological advances in electrical and computer engineering fields have made undergraduate curricula considerably more complex. Technical concepts are more abstract and can often be confusing for students trying to understand the subject matter. With the rapid growth of applications of DSP in industry, it has become necessary to introduce these concepts at an undergraduate level.

Gippsland School of Engineering, Monash University, Australia delivers engineering courses in on-campus and distance education modes. The units that are offered under various courses are supported with software simulations and interactive CAL programs, in addition to study guides, video/audio tapes, subject bulletin boards for discussions, class-room lectures for on-campus delivery and week-end summer schools for off-campus delivery. These methods lead to ideal self-paced learning alternatives for distance education students, and also provide the on-campus engineering students a better understanding of the subject compared to traditional and rigid class room lectures. Conventional class-room teaching and subject-guides suffer from lack of interactiveness and lack of interest, especially for those subjects involving rigorous mathematical analysis. This is particularly relevant for courses like signals and systems, control theory, digital signal processing, communication systems etc. which form core subjects in Electrical, Electronic and computer system disciplines and elective subjects in other engineering disciplines including Electromechanical, Mechanical and Mechatronic courses. This problem was addressed by many researchers in engineering education leading to development of various innovative teaching methods. Some of these methods involve use of standard simulation softwares [1, 2], use of structured course contents with a judicious co-ordination of theory, simulation and experimentation component [3,4], and use of specially developed multimedia based CAL programs [5,6,7,8]. For teaching digital signal processing courses in particular, work relating to extensive and expensive laboratory setups have also been reported in [9,10,11,12]. None of the techniques used have addressed the problem of delivering courses like digital signal processing in an integrated (on campus + distance education) mode.

For efficient delivery in an integrated mode a co-ordinated development of theory, simulation and experimentation is desirable, with an objective to meet the needs of wider and diverse student groups and be cost-effective at the same time. Development of courses so as to suit both on and off campus students simulataneously, with an ultimate objective to make students understand digital signal processing concepts and use it for an application is a difficult task, under the situation that these two student groups are of entirely different background. The on-campus engineering students normally have basic theoretical knowledge but no exposure to work-place or industry, and off-campus and mature-age students with good practical knowledge and hands-on skills but no theoretical background. The task is further challenging, if the course to be developed has to be offered to multidisciplinary engineering students, who have an entirely different learning objectives, in addition to different bachground knowledge. The work done by the author in development of digital signal course for on-campus and off-campus delivery to multidisciplinary engineering students is reported in this paper. The next section describes the course structure, contents, and teaching methodology adopted for the course.

2. COURSE STRUCTURE AND TEACHING METHODOLOGY

The course has a weightage of 6 credit points, with 50 % emphasis on the theoretical section and 50% on the practical component. Some of the students have the necessary prequisites which includes signal and systems theory, control theory and Laplace transformations. But, in order to cater a wider group, including off-campus and multidisciplinary engineering students, we assumed that the students do not have sound prerequisite knowledge. The review of basic concepts had to be included. This was followed by normal topics in digital signal processing like sampling theorem, z-transform, correlation between time and frequency domain. The next major topic was definition of FIR and IIR filters, realization of different FIR and IIR filters, and their advantages and disadvantages. The next topic covered was design of FIR and IIR filters. The design component included design of FIR filters using commonly used windows including Hamming, Hanning and Kaiser type. Design of IIR filters included Butterworth and Chebyshev only, and was designed with impulse invariant and bilinear transformations. To conclude, a topic on applications of digital filters in different areas was treated. This was done with an objective to make student realise the importance of digital signal processing for solving real engineering problems. The application examples included a brief description of previous student projects in finding digital signal processing solutions to biomedical, communication, industrial insoection, machine condition monitoring and speech processing areas. As all these topics have to be covered in one semester, with 50 % weightage on practicals, and the students comprising of on-campus and off-campus with diverse background and experience, it was a challenging task to plan the entire schedule for 13 week teaching semester (with 26 lecture hours and 26 laboratory hours for on-campus students and equivalent time for off-campus student consultation) and hence the teaching methodology adopted to meet the requirements was:

- Prescription of a a text book [14], which covers all the topics required and has a program disk in it (total costing less than $100). The disk with the book helps students experiment with basic concepts any time in their home computer or laboratory computer, without lecturer's involvement.

- Prescription of a reference book [15] for an in-depth study of some of the concepts and detailed design techniques in case the student is interested.

- Support with student manual guiding the student through various sections in the text, with matlab/ simulink simulation exercises and self-assessment questions for each topic. The on-campus students have an access to matlab/simulink [15] on the campus computer network and off-campus students were required to buy a copy of matlab/simulink student version, which will be useful for other subjects.

- A major component on experimental work, in which on campus students were required to implement few digital filters on low cost Texas TMS 320C50 [16] fixed-point DSP kit and also general purpose 68HC11 [17] microcontroller EVBU from Motorola semiconductors. The off-campus students have a flexibilty of buying these boards, borrowing it for a semester from the school or attending the week-end school on campus. The idea behind using two types of boards is to create an awareness about general purpose hardware alternative and more efficient dedicated hardware option for DSP applications.

- Submission of three assignments, in which first assignment was on basic concepts and few filter simulation exercises after 4 weeks. The next assignment was based on simulation as well as implementation of the FIR and IIR type filter on TMS 320C50 and 68HC11 boards to be submitted at the end of eighth week. Third assignment was on designing a filter for a particular application along with simulation and hardware implementation at the end of 12 weeks.

- Flexibility to students to choose any application case study based on their interest and background. Students doing electrical, electronics and computing major were encouraged to choose application case-study in the area of communications, biomedical, speech processing, and students with electromechanical or mechatronics major were asked to choose a case-study in industrial inspection, vibration monitoring and fault diagnosis area.

- Flexibilty in terms of choosing assembly language programming or using C-programming for implementing filters on TMS320C50 or M68HC11 EVBU. The availabilty of C cross-compilers for these boards make the programming easy for non-electrical students with no exposure to assemly language programming.

• End of the semester open-book type examination with 50% weightage where students need not rely on memory for attempting the questions but can solve them if the concepts were clear.

The entire schedule for the course delivery is as shown in table I.

TABLE I

WEEK Nos.	Topics	Practicals	Assignment
Weeks 1-4 (8 lecture hours and 8 lab hours).	Module I Sampling theorem, Ztransform , Overview of Matlab, Simulink, TMS 320C50 and M68HC11	1.Intoduction to matlab - simulink programming 2.Introduction to program assembly and downloading on 68HC11 and TMS320C50	Related to topics and practicals on module I
Week 5-8 (8 lecture hours and 8 lab hours).	Module II FIR filters IIR filters (Definition and implement ation)	Simulation and implementation of FIR and IIR type filters	Related to topics and practicals on module II
Week 9-12 (8 lecture hours and 8 lab hours).	Module III (Brief coverage) Design of FIR and IIR filters Designing a filter for an engineerin g application	Simulation and implementation of the designed filter for chosen case-study	Report submission on the design, simulation and experimenta l verificartion of the casestudy

The distance education students are supposed to have an access to multimeter, function generator and oscilloscope for doing the practical component. They have a choice of submitting the practical work at the end of the semester (after the weekend school) or provision of using the laboratory facilities of vocational colleges or laboratories close to their residence.

3. SUMMARY AND CONCLUSION

The paper reports a cost-effective integral teaching methodology for delivery of digital signal processing course. The proposed methodology:

1. Includes a suite of low-cost tools for introducing digital signal processeing to a wide group of students undertaking studies in on-campus and off-campus students.

2. Results in enthusiasm and interest from the students with any background because of flexibility in choosing the tools and application case-study.

3. Results in meeting the learning objectives of making students understand the concepts behind mathematically rigorous engineering subjects and use it for an engineering application, in fact gives a jump-start effect for learning digital signal processing .

4. Results in a self paced learning environment without a requirement of regular contact with the lecturer.

5. Further work involves developing a CAL package with multimedia animations for digital signal processing and transforming the course notes on World Wide Web (WWW) for an easy access to on-campus and distance education students, in line with Monash University's vision statement.

4. ACKNOWLEDGEMENTS

The author acknowledges the Gippsland school of engineering, Monash university for providing the facilities and infrastructure for developing this course.

6. REFERENCES

[1] D.P. Prendergast, " EDCON- An educational control system analysis and design program", IEEE transactions on Education, vol. 36, No.1, pp 42-44, 1994.

[2] F.P. Fontan, A.Seoane and M.V. Castro, " Matlab for windows software aid in a mobile communications

course", International Journal for Electrical Engineering Education., Vol.32, pp 341-349, 1995.

[3] Harold Klee and Joe Dumas, " Theory, Simulation, Experimentation: An integrated approach to teaching digital control systems", IEEE transactions on education, Vol. 37, No.1, pp 57-62, February 1994.

[4] Behnam Kamali, " Development of an undergraduate structured laboratory to support classical and new base technology experiments in communications", IEEE transactions on education, vol.37, no.1, pp 97-99, February 1994.

[5] S.R. Cvetkovic, " CAL programs developed in advanced programming environments for teaching electrical engineering", IEEE transactions on education, vol.37, No.2, pp 221-227, 1994.

[6] Philips Barker, " Multimedia computer assisted learning", Kogan Page, London/ Nichols Publishing, New York, 1989.

[7] M.A. Joordens, Evaluation of 4 CAL engineering programs", Conference on flexible teaching and learning: achieving the vision, 1994.

[8] M.A. Joordens, " The computer game effect: A factor to be considered when designing CBL programs for younger generation", Conference on flexible teaching and learning: achieving the vision, 1994.

[9] N. Dahnoun and F.S. Schlindwein, " Introducing undergraduate students to the use of digital signal processors", International Journal of Electrical Engineering Education vol. 31, no.1, pp. 66-83, 1994.

[10] Tamal Bose, " A digital signal processing laboratory for undergraduates", IEEE transactions on education, vol. 37, No.3, pp 243-246, August 1994.

[11] S.J Sangwine, "A digital signal processing laboratory based on the TMS 320C25" International journal for electrical engineering education, pp. 21-29, 1994.

[12] F. Kurugollu, H.Palaz et.al., " Advanced educational parallel DSP system based on TMS 320C25 processors", Microprocessors and Microsystems, Vol. 19. No. 3, pp. 147 - 156, April 1995.

[13] Oppenheim and Schafer, Digital signal processing, refernce book.

[14] Tompkin, Biomedical digital signal processing, Prentice Hall Publishers.

[15] Matlab for windows ®, (Classroom kit, student edition) Mathworks Inc.

[16] Texas TMS320C50 ® starter kit, manual, Texas Instruments Inc.

[17] Motorola 68HC11 EVBU, Motorola semiconductors.