

Motivating the Students to Study the Basics of Digital Signal Processing by using Virtual Learning Environment

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Introduction

Information technology (IT) made a revolution in work productivity and effectiveness. Why not use it in education? Teaching a large class is always a very challenging task for educators [1]. This is due to many difficulties imposed on the teaching - learning process. These difficulties vary from encouraging attendance, delivering well-balanced course content to keep students' interest in the subject; getting students actively participate in the learning process, and motivating students. It is possible to address the above difficulties with the help of omnipresent Internet and in recent years elaborated e-learning / e-teaching environments such as WebCT or Moodle. The proper use of IT not only enhances the students learning experience but also maximizes student productivity [1, 2]. The advantages of e-learning / e-teaching environments become very important in case of working students, part time students or practicing engineers [3].

Digital signal processing is now pervasive as it is used in everything from digital photo cameras, MP3 players, digital television, mobile phones to automobiles and advanced medical imaging equipment. However many students perceive digital signal processing as abstract mathematics [1]. Learning core concepts in signal processing courses is difficult for undergraduate students in electrical engineering [4]. This difficulty comes from the gap between understanding the mathematical formalism of such concepts and being able to make sense of them in practice [5]. To address this difficulty many "recipes" suggest "visualizing" the DSP theory with practical applications: in money management [6], speech processing image processing and array processing [5], biometrics [7], music processing [8, 9], genomics and bioinformatics [10].

Sensory stimulation theory of learning says that vast majority of knowledge held by adults (75%) is learned through seeing while hearing is the next most effective (about 13%) and if multi-senses are stimulated, greater learning because of synergy takes place [11]. This theory encouraged us to develop undergraduate level Discrete

time signal processing (DTSP) course supported by Matlab based exercises / lab works and home work projects with the application to audio processing. In this way, students are able to see the results of audio processing in Matlab plots and hear the results via computer speakers. Thus DSP related theoretical concepts (digital signal, digital system, impulse response, frequency response, digital filter, z transform, DFT) will be remembered not just as mathematical abstracts but as useful tools having sense in real world.

DTSP course position, syllabus and pedagogical approach

Signal processing is very broad discipline covering continuous time and discrete time signal processing (or digital signal processing) subjects. In higher education curriculums, it is common to start with continuous time signal processing within the course "Signals and Systems" [12] and to proceed with discrete time signal processing then to go on with general digital signal processing and finally to present advanced applications of digital signal processing methods. Figure 1 shows the signal processing related chain of courses in Telecommunications and electronics faculty of Kaunas University of Technology. The main concepts introduced in the courses are also included. It can be observed that the first two courses (together with circuit theory which is not shown in Fig. 1) cover analog signal processing part. The DTSP course fits well within the curriculum of the Electronics engineering program as it provides good background to higher level digital signal processing courses.

The DTSP course is organized in 8 lectures, 8 lab sessions of computer based exercises using Matlab and 3 homework projects. The lectures introduce theoretical aspects of DTSP concepts; lab exercises are used to train Matlab programming skills in solving DTSP problems; homework projects give the opportunity to apply the acquired knowledge and skills independently and be "rewarded" with results that can be seen and heard. Thus

the main idea of the homework projects is to motivate curiosity and working at home.

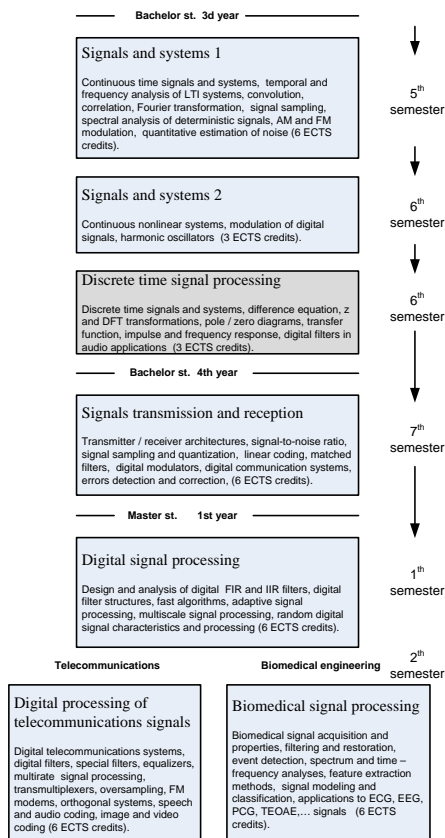


Fig. 1. Signal processing related courses in faculty of Telecommunications and electronics, KTU

The main course modules and pedagogical approach used in delivering the course is explained below.

- a) Background knowledge testing. This module is presented in the form of Self assessment test;
- b) Basics of discrete time signals and linear time invariant (LTI) discrete systems;
- c) z transform of discrete signals and discrete system function;
- d) Pole / zero diagrams in analysis and synthesis of discrete systems;
- f) Discrete Fourier Transform (DFT) and its applications. This module guides how to correlate DFT samples with their frequency, explains why DFT spectrum is symmetric, proves the periodic nature of DFT and discusses the concept of frequency resolution.
- g) Basics of digital filters. Definition of digital filter, filter specifications. Finite impulse response (FIR) and infinite impulse response (IIR) filters are compared. Windowing method is used to design FIR filter. Pole – zero placement and bilinear transformation methods to design IIR filters are explained.

Reinforcing fundamental DSP concepts with Matlab based audio exercises

It is well known that information and knowledge is grasped easier if more senses are activated during the learning process. Thus several audio DSP related

homework projects were designed with results stimulate students' visual and hearing senses. Students can see (and hear) themselves how short the path from theory to application could be. Additional goal of home work projects is to improve Matlab programming skills.

The first home work project was digital sound synthesis of musical instruments. This project teaches to program complex equation in Matlab. John Chowning noticed that fast frequency modulation of sound oscillator can produce sound with very complex spectra [13]. He suggested general mathematical model for production of vast variety of musical instruments:

$$x(t) = A(t) \cos(\omega_c t + I(t) \cos(2\pi f_m t + \phi_n) + \phi_c), \quad (1)$$

here ω_c – the carrier frequency, f_m – the modulation frequency, $A(t)$ and $I(t)$ are time dependant envelope functions. Envelope functions and selected parameters decide what kind of musical instrument is synthesized. The exponentially decaying envelope functions are suggested in case of the bell sound synthesis:

$$A(t) = A_0 e^{-\frac{t}{\tau}}, \quad I(t) = I_0 e^{-\frac{t}{\tau}}. \quad (2)$$

It is very important to show for students how knowledge acquired in previous courses relates to new knowledge. This time students can be reminded about AM and FM modulation concepts which were introduced in “Signals and systems” course and are used in communications. The students are asked to write the Matlab program implementing FM sound synthesis model, to try investigating different parameters in order to choose the set which produces the most natural sound of the bell, to write a short report and together with synthesized sound file submit electronically to e-learning system.

The second home work project was meant to connect discrete systems related concepts (difference equation, block diagram, system transfer function, impulse response) with practical application, this time with digital sound reverberator. Digital sound reverberator is used to produce synthetic reverberation effect - decaying series of signal echoes, which simulate large room acoustics. Here again students are asked to write Matlab program for recording of sound sample using microphone, implement FIR and IIR discrete systems, filter recorded sound with the discrete systems, investigate what delay produces just noticeable / pleasant reverberation effect, write short report and together with the produced sound files submit electronically to e-learning system.

The third home work project was designed to connect discrete Fourier transform with signal spectrum analysis. The practical application this time was to record noise signal produced by computer ventilators, to investigate its spectrum and to suggest the method for cancellation of strongest noise components. The students are asked to identify the frequencies of strongest noise components then to investigate and discuss the frequency resolution of the spectrum. By using this enquiry based scenario the students approach to the problem: how to cancel the strongest noise components? Some students successfully implement the method in Matlab using offline mode, but face with the problem in real time mode. The noise

sometimes gets even stronger... Interested students are suggested to use computer sound card based open source virtual instrument *VisualAnalyser* [14] which is able to measure signal spectrum and generate the arbitrary form signal in real time. Challenging project should raise curiosity and the desire to learn more, even outside what is expected.

Course implementation in e-learning environment

The first version of the DTSP course was implemented in WEB CT environment. Because of the changes in university policy, we are now in the process of moving the course to free, open source virtual learning environment (VLE) - Moodle. In our opinion, both VLEs are similar in features with Moodle being a bit more flexible while WEB CT is more “prestructured” thus it can be characterized as having steeper learning curve.

DTSP course is structured in the “theme format”. The themes have lecture slides in pdf format, descriptions of lab works and homework projects in MS Word format, dedicated discussion “Forums” and “Assignment” tools with possibility for students to upload electronic reports.



Fig. 2. The example of thread in one of discussion forums

Students usually have 3 – 4 weeks to complete the lab works with home work projects and to write the reports. The reports submission deadlines are embedded in Assignment tool and are very strict. The deadline time is chosen as midnight before the next lab work to emphasize the strict deadline even more.

Both virtual learning environments allow hiding parts of the course contents. It is important feature which helps gradually introduce students with the course contents and saves them from discouraging flood of information especially in the beginning of the course.

Usage of discussion forums in e-learning environment to support and motivate students

In order to keep motivation of students, it is very important to show constant interest in their work and to provide timely support when problems arise. Thus to each homework assignment separate discussion forum was dedicated. Students were able to ask questions, other students were encouraged to provide answers. It was

announced that the activity in forums will be assessed positively. There were mainly Matlab programming issues related questions. Sometimes it was enough to say “look it up in the forum, there was such question already”. More than 100 questions were raised in the three assignments (see an example of one discussion thread in Fig. 2).

Tools for student assessment and course assessment

Students get 3 grades for three MATLAB home works. The final grade is 50% of the exam and 50% of the average of home work grades. However, the grades must be rounded to the integer often. Student tracking tools can help to make grades rounding decisions. Student activity reports show how active student was during selected time period, how many posts he made in the forums, what VLE resources and for how long he was using? Students are provided with grades in the Moodle grade book as soon as the assignment or quiz is graded. This feature helps to show the present state and the progress students have made; motivates them to study the materials systematically.

In order to keep the course current it must be constantly upgraded. Students may be asked to provide feedback about the course. Modern VLEs have a tool “Anonymous survey” which suits very well to this purpose. Students must be informed about anonymity of the survey in order the collected opinions be as objective as possible. We have results from 2008 and 2009 years (38 responses). The answers suggest such conclusions: 1) all students have computer connected to the internet at home, 2) most of students English language knowledge is “good”, 3) 30% of students are working, 4) 90% of students would like other courses use VLE systems, 5) 90% of students are happy with the support from the teacher, 6) 82% think that final grade is adequate to their efforts, 7) 100% appreciate usage of Matlab in lab works.

Conclusions and future work

Education innovations such as effective e-learning systems and pedagogical strategies which make strong connections between theory and real-life applications should help to attract, excite, and retain students in electrical engineering programs. We believe that the nature of DTSP course allows to implement it as motivating and attractive for students.

In the future, we will complement each lecture with self assessment tests and intelligent feedback. The tests will be automatically graded and results collected in e learning environment’s grade book. We anticipate that frequent small rewards in terms of accumulative grades will help the students to stay motivated.

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The course “Discrete time signal processing” might seem for students as being quite theoretical and difficult to understand. We have introduced several innovations into the course at the beginning of the year 2008. This paper describes the experience in teaching the basics of discrete signal processing by using MATLAB based projects involving synthesis, processing and analysis of sounds as well as the variety of tools available in virtual learning environment. It is well known that information and knowledge is grasped easier if more senses are activated during the learning process. Thus several lab works were designed with the goal to synthesize the sound of the bell, to design the digital reverberator, to analyze the noise of computer ventilators and others. Modern virtual learning environments (Moodle, WebCT) are usually used mere as depositories of learning materials. In our case, we used almost all the tools available in the virtual learning environment including: assessments, assignments, discussion forums, electronic submission of lab reports, announcements and usage statistics reports as the teacher tool. The anonymous course evaluation results by the students are presented in the final part of the paper. III. 2, bibl. 14 (in English; abstracts in English, Russian and Lithuanian).

V. Марозас, В. Думбрава. Мотивация студентов к изучению основ цифровой обработки сигналов с помощью виртуальной среды обучения // Электроника и электротехника. – Каунас: Технологія, 2010. – № 6(102). – С. 87–90.

Курс “Обработка дискретных сигналов”, для студентов может показаться совершенно теоретическим и трудно понятным, поэтому в начале 2008 года мы ввели ряд новшеств. В этой статье описывается опыт преподавания основ дискретной обработки сигналов с помощью на MATLAB основанных проектов с применением синтеза, обработки и анализа звуков, а также различные инструменты, имеющиеся в виртуальной учебной среде. Хорошо известно, что информация и знания понимаются легче, если больше чувств активизируются в процессе обучения. Таким образом, несколько лабораторных работ было разработано с целью синтезировать звук колокола, а также имитировать цифровой ревербератор или анализ шума компьютерных вентиляторов и других шумов. Современная виртуальная среда обучения (Moodle, WebCT) обычно используются в качестве простого хранилища учебных материалов. В нашем случае использовались почти все инструменты, имеющиеся в виртуальной учебной среды в том числе: оценки, задания, форумы, электронная подача отчетов лаборатории, анонсы и отчеты, статистика использования в качестве инструмент учителя. Анонимные оценки студентов о курсе представлены в заключительной части статьи. Ил. 2, библи. 14 (на английском языке; рефераты на английском, русском и литовском яз.).

V. Marozas, V. Dumbrava. Studentų motyvacija mokytis skaitmeninio signalo apdorojimo pagrindų naudojant virtualią mokymosi aplinką // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2010. – Nr. 6(102). – P. 87–90.

Diskretinių signalų apdorojimo kursas studentams gali atrodyti grynai teorinis ir sunkiai suprantamas, todėl nuo 2008 metų pradžios į tokį kursą esame įdiegę keletą naujovių. Aprašytas diskretinių signalų apdorojimo pagrindų mokymas naudojant MATLAB programinę įrangą ir terpę, kurioje panaudota virtualių mokymosi aplinkų įvairovė, taikant sintezės, garsinių signalų apdorojimo ir analizės priemones. Gerai žinoma, kad informacija ir žinios įsisavinamos lengviau, jei mokymosi procese aktyvuojama kuo daugiau pojūčių. Taigi, buvo sukurti keli laboratoriniai darbai, kurių viename sintezuojamas varpo garsas, kitas buvo skirtas skaitmeninio reverbatoriaus darbui modeliuoti, trečiasis darbas skirtas kompiuterių ventiliatorių keliamo triukšmo analizei. Šiuolaikinės virtualios mokymosi terpės (Moodle, WebCT) paprastai naudojamos tik kaip mokymosi medžiagos saugykla. Šiame darbe panaudoti beveik visi virtualios mokymosi aplinkos įrankiai, įskaitant užduočių vertinimą, diskusijų forumus, elektroniniu būdu pateiktus laboratorinių tyrimų rezultatus, pranešimus ir studentų aktyvumo statistikos ataskaitas kaip dėstytojo kontrolės priemonę. Baigiamojoje straipsnio dalyje pateikti anoniminiai studentų kurso vertinimo rezultatai. Il. 2, bibl. 14 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).

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