Curricula Development for Parallel Architectures and DSP and Teaching Activity in Advanced Studies (MSc) in Communications Department of Technical University Cluj-Napoca (Romania)

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Abstract
The paper presents several fundamental aspects of DSP teaching in Communications Department of the Technical University Cluj-Napoca (Romania): structure of the course, projects, practical works.
The paper also presents other related background courses in DSP and Parallel Architectures.

Communications Department of Technical University Cluj-Napoca - short profile

The Communications Department was founded in 1990, as a result of the necessity to improve the students education in a very dynamic field: telecommunications. The Department is part of the Faculty of Electronics and Telecommunications.
Main Groups of the department are :

- Microprocessors Systems Design, Communications Techniques, Computer Networks
- Information Theory, Telephony
- Television, Image Processing, Multimedia Systems and Applications
- Switching Systems, Broadband Networks, Digital Networks in Telecommunications
- Microwaves, Radio Communications, Mobile Communications
- Programming, Operating Systems, Software Engineering
- Data Transmission, Communications Techniques, Advanced Techniques in Digital Transmission
- Telephony Transmission Systems, High-Speed Transmission Systems, Neural Networks in Telecommunications
- Speech Processing, Programming
- Microprocessors Systems Design, Speech Analysis and Synthesis
- Satellite Communications
- Image Processing
- Audio-Video Systems, Data Recording

Scope of the DSP and Parallel Architectures teaching

Study of DSP and parallel architectures in Electronics and Telecommunications faculty begun 5 years ago, simultaneously with Advanced (MSc) studies founding.

The main goal of the main course and related courses are to give to attendants the most important concepts in Digital Signal Processing (speech, data, video), and related technology (DSP chips) and to present practical possibilities of those technologies.

Teaching process includes not only the main course, but also few other background courses and specialty courses. The following diagram illustrates the process.

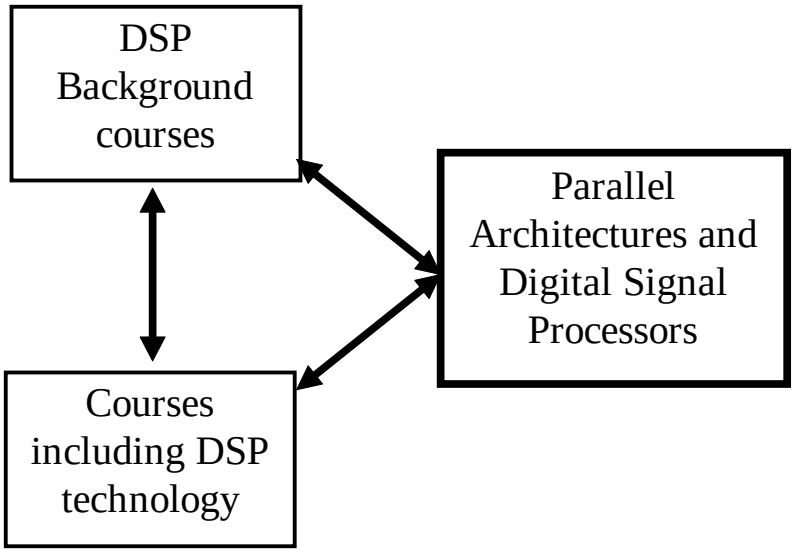

Fig.1 DSP teaching process

Preliminary courses related to DSP ([1],[2])

The course specifically assigned to DSP techniques and architectures is intended to be lectured in Advanced Studies (Msc) Cycle (6th year of studies). DSP techniques are briefly presented in other different courses in early years (B.Sc. degree). Here are some of them.

Microprocessor Systems II course - Prof. Gavril Toderean
Interfaces - serials and parallels. Timer, DMA, floppy disk management. Implementation of the combinational and sequential circuits programs. Microcontrollers Intel (8051). Applications. The architecture and the assembler language. The I2C bus. DSP - TMS320CX, architecture and assembler language. Applications.

Communications Techniques course - Prof. Gavril Toderean
Modem - computer interface. Baseband modems, coding, synchronization, decoding. FSK Modems. Modulation, demodulation, synchronization. PhSK Modems. PCM - modulation

and delta modulation Linear modulation and demodulation Exponential modulation and demodulation.

Data Transmission course - Assist. Prof. Vasile Bota
Partial response techniques (PR signaling). Data transmissions employing linear modulation. Quadrature Amplitude Modulation (QAM). Combined PSK-AM modulation. Trellis coded modulation (TCM). Common modem functions. GMSK modulation for radiomobile transmissions. Channel equalisation. Echo cancellation for data transmissions over telephone channels. COFDM transmissions.

Mobile Communications - Assist. Prof. Tudor Palade
Cell coverage for signal and traffic. Cell site antennas and mobile antenna. Cochannel interference reduction. Frequency management and channel assignment. Handoffs. Operational techniques and technologies

Digital Speech Processing course - Assist. Prof. Mircea Giurgiu
Speech features. Models for speech production. The analysis in time and frequency domain. Linear Predictive Analysis. Partial Correlation Analysis, Line Spectrum Pairs Analysis. Cepstral Analysis. Speech Coding and Compression in time and frequency domain. Speech coding for Mobile Communications.

Image Processing - Prof. Aurel Vlaicu
TV signal acquisition. 2D sampling and quantisation. Image transforming. Image analysis and pattern recognition. Image compression and coding.

Advanced study (Msc) is dedicated to highly specialized techniques in Telecommunication. Besides the main DSP course, several other courses complete the education in Digital Signal Processing and related techniques.

Software Engineering - Assist.Prof. Mircea Vaida
Multimedia Software Engineering. Software Engineering under Windows. Creating a Windows Application. Multimedia Applications and Signal Processing.

Speech Analysis and Synthesis - Assist.Prof. Eugen Lupu
Speech production mechanism. Speech analysis (STFFT, LPC, cepstral, Bank of digital filters). Pitch and formants extraction. Speech compression. Speech synthesis. Aspects on speech recognition (DTW, Vector quantisation, HMM, Neural Networks). Speaker recognition.

Course topics ([3], [4])

The course is named officially "Parallel Architectures and Signal Processors" (PASP.104.EC.27.01-M2).

The course has 12 weeks, consisting weekly from 2 hours of lectures, 1 hour of practical works and 1 hour project.

The lecture approximately covers the following topics:

1. Introduction in concepts and architectures used in digital signal processing
2. Parallel architectures specialized in digital signal processing
3. Digital signal processors (general topics)
Processing architectures : von Neuman (SISD), Harvard, SIMD, MIMD. Comparison: CISC-RISC vs.Transputers. DSP types:fixed point , floating point. TI DSP family.

4. Fixed point DSP fundamentals (structure of TMS320C25 family)
Internal architecture. External connections. Memory organization. Peripherals. Interrupts.

5. Instruction set of TMS320C2x family ([6])
Addressing modes: direct, immediate, indirect, bit-reverse.
Instructions. COFF format . Q15 representation.

6. Other DSP structures (enhanced fixed point-TMS320C5x, C54x , floating point- 3x,4x families, high performance 8x, 6x)
Internal architecture- improvements compared with C2x. Hardware implementation of loops.
Memory organization. Interrupts.. Addressing modes. Instruction set.
MVP TMS320C80 - internal architecture.
TMS320C54x . Architecture . Improvements.
TMS320C6x . VLIW Architecture -VelociTI. C6201 chip.

7. Mathematical fundamentals of filter and FFT design
Digital filters. FIR filters. IIR filters.
FFT- proprieties. Base algorithm. Fast algorithms.

8. Interconnection in DSP systems (high performance buses)
Presentation of IEEE-1394 high speed bus.

9. Testing DSP based systems (Jtag interfaces)
Presentation of JTAG IEEE-1149.1.

10. Practical applications using DSP (Modems, Digital Control, Image processing)
Applications: signal generation, sinus, LP filter. DSP based instrumentation.

Practical Works

Practical works covers the following topic:
1. Study of a DSP based development system (DSPxx25 [5] - board developed at Software ITC -Cluj-Napoca Romania)
2. Study of other fixed point DSP based on TMS320C50 TI Starter Kit. Applications based on TI starter kits.
3. Study of software tools for DSP application development (COFF environment)

4. Applications using DSP (Waveform generation, Signal acquisition)

Projects

Projects cover individual study of other architectures and tools used in DSP, study of practical applications (modems, digital control), the students writing works on those subjects. The most interesting works are presented in a special session of the course.

We present shortly few projects completed by students in the past years.

- Form factor (image processing) computation on fixed point DSP
- FFT implementations on fixed point and floating point DSP
- Modulation techniques simulated an implemented on DSP
- Interfaces for data acquisition in DSP environment
- DCT implementation on fixed point DSP
- JPEG-like algorithms implementations on fixed point DSP

Lecturers

In the first 4 years, the course was sustained by Dr.Radu Arsinte from Software ITC Research Institute , in the last year being sustained by Dr.Eugen Lupu from Technical University Cluj-Napoca. Both of them have graduated one or several TI technical workshops in DSP.

Future developments

Course topics are rapidly evolving, every year at least 20-25 % of his content being updated, to maintain the contact with domain changes.

In the future the course probably will be focused on new DSP chips, the impact of DSP techniques on telecommunication techniques, analysis of typical applications based on DSP. Topics as DSP Bios will be also considered.

More information on DSP Curricula in Communications Department of Technical University Cluj-Napoca can be found at : *http://www.utcluj.ro*

More information on other DSP based applications developed in co-operation with the Communications Department can be found at : *http://www.sitc1.dntcj.ro*

Literature

[1]***	Curricula of BSc in Telecommunications - Technical University Cluj-Napoca 1998-1999
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[4]Eugen Lupu	Parallel Architectures and Digital Signal Processors - Course Notes - Technical University Cluj -Napoca 1999
[5]Radu Arsinte	DSPxx25 Board - Instruction Manual - Software ITC - 1995
[6]Eugen Lupu, Tiberiu Miclea, Radu Arsinte	“Digital Signal Processors - TMS320C2X generation - presentation and applications “(in Romanian) -Promedia Publishing House -Cluj-Napoca ,Romania -1995