On the development of the digital world

Memories of signal processing research with Yrjö

Olli Simula
Beginning of the DSP research

• In mid 1970s active research on computationally efficient digital filter structures was started at Helsinki University of Technology, TKK:
  – Yrjö had returned from USA at the end of 1973
  – I had finished my Master’s Thesis on DSP in January 1974
  – In January 1974, we formed the DSP group at the Department of Technical Physics
  – I started doctoral studies under Yrjö’s supervision
Main goals of the research

• Design of computationally efficient digital filter structures
  – Low coefficient sensitivities
  – Small number of multiplications

• Hardware implementation of digital filters
  – Real time implementations needed for industrial applications
  – Fast microprocessor circuits suitable for DSP became available in 1970s
NRS 290 Microprogrammable Digital Filter

- **NRS** stands for the design team: Neuvo, Ropponen, Simula
- **290** stands for Am2900 circuit family by Advanced Micro Devices in 1975
Examples of NRS 290 circuit boards

Multiplier  
ADC + MUX  
CPE ALU and DATA RAM
NRS 290 Microprogrammable Digital Filter

• Design objectives:
  – High performance
  – Ease of programming a variety of modular DSP algorithms

• Design specifications:
  – Efficient microprogrammed implementation of a basic filter module
  – Filter realization form defined in the microprogram
  – Higher order filters implemented by looping the basic module
  – Basic module multiplexed up to 16 channels to implement a filter bank
NRS 290 performance measurements

- Measured microinstruction cycle time 195 ns which was 35 ns less than estimated
- Computation time of 4.1 µs for a standard 2\textsuperscript{nd} order block was obtained
- For a full filter bank of 16 4\textsuperscript{th} order filters the computation time of 131 µs was achieved
- The corresponding sampling rates for the 2\textsuperscript{nd} order block and the full filter bank were 244 kHz and 7.63 kHz
- The performance was well comparable to high-speed hardware digital filters of the 1970s
Impact of NRS 290 project

• The research cooperation between industry and universities was important for the future development of telecommunications and mobile phone industry
Academic output of early DSP research

• The first doctoral thesis on DSP supervised by Yrjö came out in 1979
• It was followed by several DSP dissertations at Tampere University of Technology, e.g., by Tapio Saramäki, Markku Renfors, Kari-Pekka Estola etc.
Teaching DSP

• In 1974 Yrjö started a basic course in DSP
• The course was based on the manuscript of the classical textbook by Oppenheim and Schafer (1975)
• I continued the teaching after Yrjö left to Tampere, until my retirement in 2013
Nordic cooperation in DSP research and education

• Strong Nordic cooperation in 1970s and 1980s
• Main participants:
  – Helsinki & Tampere Universities of Technology (Neuvo, Simula)
  – Linköping University (Fjällbrant, Wanhammar, Eriksson)
  – Norwegian Institute of Technology, Trondheim (Ramstad)
• Several symposia and conferences were organized jointly starting from the 1970s
• Nordic intensive courses on DSP algorithms for doctoral students, e.g., in Trondheim 1986
1988 IEEE International Symposium on Circuits and Systems, ISCAS-88

ISCAS-88 was the largest ISCAS ever...
THANK YOU YRJÖ!