The Technical University of Košice

Faculty of Electrical Engineering and Informatics

Annual Report 1995

Department of Radioelectronics

THE TECHNICAL UNIVERSITY OF KOŠICE

Faculty of Electrical Engineering and Informatics
(Slovak Republic)

DEPARTMENT OF RADIOELECTRONICS

ANNUAL REPORT 1995

Edited by Ľuboš Ovseník

Contents

1. INTRODUCTION

The Department of Radioelectronics was founded in the year 1969.
The number of student studying in the Department is approximately 18O.
The basic research of the Department concentrates on digital signal processing mainly digital picture and speech processing and transmission, optoelectronics systems and optical communication, implementation of neural networks in digital processing and communication, digital filtering, ADC modeling and statistical sensors.

2. FACULTY

Head : Prof. Ing. Dušan Levický, CSc.

Assoc. Heads : Prof. RNDr. Ing. Ján Turán, DrSc.
Doc. Ing. Stanislav Marchevský, CSc.

Full professors : Prof. Ing. Dušan Levický, CSc.
Prof. Ing. Linus Michaeli, CSc.
Prof. RNDr. Ing. Ján Turán, DrSc.

Full professor Emeritus: Prof. Ing. Viktor Špány, DrSc.

Associated professors: Doc. Ing. Anton Čižmár, CSc., Dean of the Faculty of Electrical Engineering and Informatics,
Doc.Ing. Dušan Kocur, CSc.,
Doc. Ing. Stanislav Marchevský, CSc.,
Doc. Ing. Ján Mihalík, CSc.

Assistant professors: Ing.Ľubomír Doboš,CSc., Ing.Miloš Drutarovský, CSc., Ing. Pavol Galajda, CSc., Ing. Ján Gamec, CSc., Ing. Milan Chudáčik, CSc., Ing. Jozef Juhár, CSc., Ing. Ján Šaliga, CSc., Ing.Jozef Zavacký, CSc., Ing. Iveta Gladišová, Ing. Zita Klenovičová, Ing. Ľudmila Maceková, Ing. Emil Matúš

Research Staff : Ing. Ingrid Hroncová, Ing. Ľuboš Ovseník

Ph.D. Students : Ing. Peter Böhmann, Ing. Martin Dulina, Ing. Jozef Dzivý, Ing. Tomáš Frič, Ing. Milan Guzan, Ing. Jozef Hámorský, Ing. Gabriel Hanko, Ing. Miroslav Jacko, Ing. Peter Kalakaj, Ing. Ladislav Kövesi, Ing. Mikuláš Kövesi, Ing. Peter Král, Ing. Igor Kuba, Ing. Rastislav Labovský, Ing. Róbert Probstner, Ing. Jozef Raček, Ing. Viliam Segeďa, Ing. Andrej Šak.

3. COURSES GIVEN IN 1995

Subjects	Winter semester	Summer semester	Lecturer
2nd year of study			
Electronic Devices	X		Marchevský
3rd year of study			
Digital Electronics		X	Levický
Acoustics	X		Juhár
Electronics and Transmission of Information	X		Doboš, Čižmár
Linear Analog Circuits	X		Kocur
Non-Linear Analog Circuits		X	Michaeli
Signals and Systems		X	Mihalík
Design of Electronic Equipment	X		Doboš
Microwave Technology	X		Turán
Communication Systems		X	Čižmár
4th year of study			
Microprocessors in Electronic systems	X		Levický
VLSI Processors		X	Levický
Communication Systems		X	Čižmár
Digital Filtering		X	Kocur
Radioelectronic Measurements	X		Michaeli
Analog & Digital Interfaces		X	Michaeli, Šaliga Čižmár
Digital Signal Processing	X		Mihalík
TV Systems	X		Marchevský
Optoelectronics	X		Turán
Optoelectronic Communications		X	Turán
Signal Recording		X	Juhár
5th year of study			
Digital Voice Communication Systems	X		Čižmár
Telematic Systems	X		Levický
Radioelectronic Systems	X		Doboš
Sensor Systems	X		Michaeli
Digital Image Communication Systems	X		Mihalík
Medical Electronics	X		Michaeli
Photonics	X		Turán
HDTV & Cable TV Systems	X		Marchevský

4. Research Laboratories

4.1. Laboratory of Digital and Communications Systems

Staff

Head: Full prof. **Prof.Ing. Dušan Levický, CSc.,** Member of the IEEE
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Communication Systems, Digital Voice Communication Systems

Assist. prof. **Ing. Zita Klenovičová**
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Digital Electronics

Assist. prof. **Ing. Emil Matúš** e-mail: matus@ccsun.tuke.sk
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Telematic systems, Microprocessor in Electronic Systems

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Ph.D. Students:

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Ing. Peter Böhmann
Ing. Peter Král
Ing. Peter Chromek (distance form)

Research activities:

Research project No.41141

Digital Methods for Signal Preprocessing and Transmission

Research project No. 2312/95

Intelligence Signal Processing in Telecommunication

Supervised by Prof.Ing. D.Levický, CSc.

The projects are oriented towards to digital signal processing in field digital picture processing, digital speech processing and digital filtration.

Progressive image compression

Scientific staff: D.Levický, Z.Klenovičová, P. Král

Progressive image compression is very important technique in image processing. In this special mode of image processing is image encoded in multiple scan and receiver built up progressively better approximation of original images. Progressive encoding has applications in the three main areas. One application is in image databases serving output devices with widely differing resolution capability. Storing the database images in progressive form only that information in the compressed image required for reconstruction to the resolution of the display is transmitted and decoded. A second application for progressive image coding is in image browsing over medium rate communication channels. A low resolution image can be rapidly transmitted and displayed and then followed by as much resolution enhancement as is desired. Each stage of resolution enhancement builds on the previous stage. A third application for progressive coding is in packet networks where packets can or must be classified as droppable or non-droppable. Priority classification is being considered for broadband ISDN.

In the field of progressive image compression the main methods for image decomposition using image hierarchy in the space domain bit planes, tree search vector quantization (TSWQ) and pyramids were analyzed. The new method for set of Gray codes generation was proposed. The set of Gray codes as well as arithmetic code in bit planes coding were used

for progressive image compression. The nonoverlapping pyramid 2x2, overlapping pyramids 4x4 as well as the Gaussian and Laplacian pyramids for progressive image transmission and reconstruction were used.

The best results in sense of image compression and speed of image reconstruction were obtained by means TSWQ. The new method for code book in TSWQ was proposed.

The fractal image compression for progressive image transmission and reconstruction was analyzed too.

Intelligence Signal Processing in Communication

Scientific staff: D.Levický, E.Matúš, P.Král

Image compression methods perform two main operations: removal of statistical redundancy and reduction of (visual) irrelevancy to achieve a low-bit rate. These operations are conceptually orthogonal, but some coding techniques combine both approaches.

The image coding methods based on computational models of visual information processing have been termed as second generation methods. Indeed, it is very interesting to derive the image coding algorithms from the models of biological visual processing. Visual pattern image coding (VPIC) is the image coding technique offering high compression at low complexity. In this technique a set of visual patterns is defined, based on a simple viewing geometry model. The patterns used in VPIC are defined independent of the images to be coded and produce good image quality according to perception. Furthermore, to improve of a compression efficiency vector quantization is may exploited in some of these methods. Artificial neural networks (ANNs) inspired from neural networks of live organisms can enhance the adaptability of a coding systems and have the possible feasibility of real-time operation by a massively parallel implementation. In this field a new modification of visual pattern image coding was proposed. Proposed

modification is based on using neural networks for visual patterns and vector classification. The Hamming neural network and a modification of Kohonen's unsupervised LVQ algorithm are used.

For the image transmission are very interesting the hybrid image techniques. We proposed a new idea of a two layer hybrid image coder based on visual pattern image coding of original image and residual image by means of the wavelet transform. At first the contours are extracted from the original image. As a contour extractor a VPIC coder is used. In the second, the residual image is computed and coded by wavelet transform. In the decoder side the sum of contours and residual (texture) image parts is made to obtain the reconstructed image. For the simulation the picture LENA was used. The proposed coding technique is well suitable for image coding and progressive image transmission.

Speech and Channel Coding and Neural Networks in Communications

Scientific staff: A.Čižmár, I.Hroncová, J.Hámorský

Applications of speech coding today have become very numerous. A few examples are listed here: mobile satellite communications, cellular mobile radio, voice/data multiplexers for public and private networks, rural telephone radio carrier systems, audio for videophones or video teleconferencing systems.

In the last two decades of our century a great deal of effort was dedicated to the development of new coding methods for speech signals. Among many methods proposed so far the transform coding (TC) can be distinguished as a compromise between waveform coders and vocoders. The advantage of the TC over waveform coders is its lower bit rate and over vocoders is its ability to code efficiently also non-speech signals where result of vocoders is very poor.

Proceeding from these facts, a new modified transform coder was

proposed. It is based on mixed TC using constrained basis representation and voiced / unvoiced / silence detection. This coder can adaptively allocate the number of retaining dominant transform components for each transform in mixed transform coder due to the different type of speech segment. A bit rate reduction can be reached because of the possibility to transmit silence only with a small number of transform components. This way a variable bit rate can also be obtained.

For unequal error protection the use of rate compatible punctured convolutional (RCPC) codes has been suggested. Some experiments have been done with Turbo Codes as a new class of convolutional codes.

Neural networks, because of their massively parallel and adaptive nature, can adapt to changes in data and learn the characteristics of an input signal. Neural networks can be used in pattern classification by defining nonlinear regions in the feature space.

High-speed data transmission over channels with amplitude and delay distortion has become a common practice due to the development of adaptive equalization techniques based on the linear finite impulse response channel model. Channel equalization is an inherently non-linear problem and it is desired to incorporate some non-linearity in the equalizer structure. By contrast, channel equalization can also be viewed as a classification problem where an equalizer is constructed as a decision-making device to reconstruct the transmitted symbol sequence as accurately as possible decision making. The ability of multi-layer perceptrons to realize a wide variety of classification mapping provides the basis for their use as adaptive equalizers we have investigate the ability of changing the MLP decision region by controlling the threshold-level of the hard-limiting quantizer which follows the output of MLP and which is used to produce a binary output. Carpenter-Grossberg neural network model has been investigated in the area of speech waveform clustering to produce a codebook for bit-rate-reduction.

International Cooperation

Continuous Speech Recognition Over the Telephone

Research project: COST 249
Supervised by Doc.Ing. A.Čižmár, CSc.
Scientific staff: S.Marchevský, D.Kocur, I.Hroncová, M.Drutarovský

The main objective of the project is to co-ordinate research efforts in the area of multilingual continuos speech recognition for future public network services. This will be accomplished by establishing a unified language-independent speech recognition concept, and be investigating specific topics within the framework of this concept.

This research project is proposed as a 4-year action, and the work packages can be described in terms of the concepts or the kind of processing being addressed:

Working Group 1: Concept Establishment

Working Group 2: Linguistic Processing

Working Group 3: Phonetic Decoding

Working Group 4: Acoustic Signal Processing

COST 249 is common project of teams at universities and private firms from foreign countries as follows: Belgium, Czech republic, Denmark, France, Germany, Hungary, Ireland, Italy, Lithuania, The Netherlands, Norway, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

We are involved in the Working group 4 - Acoustic Signal Processing.

The quality and intelligibility of speech is often degraded by background noise, by coding noise, by noise due to transmission over a channel with non-linear intersymbol interference, and by the presence of speakers other than the desired speaker. The aim of speech enhancement, noise suppression,

and transmission-line equalization techniques is to process the degraded speech such that its intelligibility and quality are improved.

The research of the group is oriented towards the fields:

a) speech enhancement and noise suppression technique
   - time/frequency domain adaptive filtering
   - linear adaptive filtering
   - nonlinear (Volterra) adaptive filtering
   - neural networks based noise reduction
   - frequency domain adaptive postfiltering

b) transmission-line equalization techniques:
   - equalization of channels with non-linear intersymbol interference by multi-layer perceptron.

As fields of possible applications are defined:
   - presence of background noise in an automatic recognition systems
   - crosstalk and echo noise in telephone systems
   - co-channel noise in a cellular mobile telecommunications systems, etc.

In the COST 249 project is involved a staff of Department of Cybernetics and Artificial Intelligence.

ISMAN - Integrated Services Metropolitan Area Networks
COPERNICUS Project: COP 587
Supervisor: Doc. Ing.Anton Čižmár, CSc.
Scientific staff: D. Levický, J. Juhár, I. Hroncová

The main objective of ISMAN project is to define the architecture of a multiservice communication network across a metropolitan area based on advanced technologies such as ATM in order to provide data, voice, and TV services to residential, public administration, and business customers. The analysis of different scenarios for Krakow (Poland) and Košice (Slovak Republic) will take into account the existing infrastructure, broadband and

narrowband services capabilities, security, economical aspect and logistic aspects of such a network. Multimedia services and telematic applications profiles will be implemented in order to evaluate the network global performance.

So for a full description of present network characteristics in Košice was made as well as a detailed description of the general technical and economical environment in which the metropolitan area will be deployed.

Partners:

LORACOM (Association Lorraine du Centre d'Igenierie des Technologies de la Communication), University of Nancy, France

University of Mining and Metallurgy, Dept. of Telecommunications, AGH Krakow, Poland

University of Catania, Italy

Technical University of Košice, Dept. of Radioelectronics, Slovakia

Comarch Co.Ltd., Poland

Data Processing Centre of Krakow Voivodship Office, Poland.

TELECOMNET - Telecommunication network and services

TEMPUS Project: JEP-09326-95
Local coordinator: Prof. Ing. Dušan Levický, CSc.

Partners of the project:

Slovak Technical University, Bratislava, Slovakia

University of Transport and Communication, Žilina, Slovakia

Technical University, Košice, Slovakia,

Universidad Politécnica de Cataluna, Barcelona, Spain

Politecnico di Torino, Torino, Italy

Slovak Telecommunication, S.T., Bratislava, Slovakia

Alcatel Business Systems, Bratislava, Slovakia

Siemens A.G., Wien, Austria

Alcatel Sel, Stuttgart, Germany

General Objective

Complex restructuring of the degree course Telecommunication Technologies at three technical universities in Slovak Republic (STU Bratislava, UTC Žilina and TU Košice) at the level of undergraduate and postgraduate study, as well as at the level of continuing education.

Goals of the Project

(i) Curriculum development of the degree course Telecommunication Technologies

- M.Sc Study
- Ph.D. Study

(ii) Curriculum development for continuing education course in the area of telecommunication technologies

- Creation a system of continuing education

(iii) Development / modernization of subjects for the degree course Telecommunication Technologies and for continuing education in the area of telecommunication technologies

- Development / modernization of subjects for M.Sc and Ph.D. study
- Development / modernization of subjects for continuing education

(iv) Establishment of training centers

Members

Prof. Ing. Levický Dušan, CSc., member of the editorial board "Radioengineering".

Doc.Ing.Čižmár Anton, CSc., member of Technical Standardization Commission No.41 for Telecommunications in Slovakia.

Doc.Ing.Čižmár Anton, CSc., member of AES (Audio Engineering Society), New York, I.D. 44 154.

Other Activities

Doc.Ing.Čižmár Anton, CSc., chairman of Electronic Section of EMES Conference, June 2-4th, 1995, Oradea, Romania.

PUBLICATIONS

Journal Papers

Levický, D. - Matúš, E. - Král, P.: A Two Layer Hybrid Image Coder. Radioengineering, Vol. 4, No. 1, April 1995, pp. 2-6.

Levický, D. - Král, P.: Neural Networks in Visual Pattern Image Coding. Neural Network World. Vol. 5, No. 2, pp. 163-169.

Levický, D.: 25 Years of the Radioelectronics Education at the Technical University in Košice. Radioengineering. Vol. 4, No. 1, April 1995, pp. 1.

Conference Papers

Levický, D.: Some New Approaches in Still Image Compression and Transmission. Proc. of the 1st. Int. Conf. on Telecommunication Technologies, Bratislava, 31.5.-1.6.1995, pp.193-198.

Matúš, E. - Levický, D.: A Method for Block Image Coding. Proc. of the 1st. Int. Conf. on Telecommunication Technologies, Bratislava, 31.5.-1.6.1995, pp.199-200.

Klenovičová, Z. - Levický, D.: Modifikované kódovanie bitových rovín Grayovými kódmi. (Modified Coding of bit planes using Gray Codes.) Proc. of the 1st. Int. Conf. on Telecommunication Technologies, Bratislava, 31.5.-1.6.1995, pp.72-73.

Levický, D.: Niektoré nové smery v kódovaní a prenose číslicových obrazov. (Some New Approaches in Image Coding and Transmission.) T.I.S. '95, 3rd Int. Conf. with Exhibition, Žilina, 13.6.-16.6.1995.

Levický, D. - Drutarovský, M. - Galajda, P. - Kocur, D. - Marchevský, S.: Adaptive Goertzel's Algorithm for Harmonic Power Voltage. 40. Internationales Wissenschaftliches Kolloqium 18.9.-21.9.1995, Ilmenau, pp. 473-478.

Čižmár,A.: The Use of Neural Nets for Channel Equalization without and with Decoding. Proc. of Int. Conf. "Telekomunikácie '95", May 31st - June 1st, 1995, Bratislava, Slovakia, pp. 101-105.

Hroncová,I.-Čižmár,A.: Comparison of Time - Consumption and Efficiency of Several Types of Transforms for 1D DSP. Proc. of Int. Conf. "Telekomunikácie '95", May 31st - June 1st, 1995, Bratislava, Slovakia, pp. 187-192.

Hroncová,I.-Čižmár,A.: A Time-Consumption and Efficiency of Several Discrete Types of Transforms. Bulletin for Applied Mathematics 1064/95, May 5-7th, 1995, Budapest, Hungary.

Hroncová,I.-Čižmár,A.: Efficiency of Digital Signal Processing by Different Types of Transforms. Proc. of EMES (Engineering of modern Electric Systems '95.) ISSN-1223-2106, June 2-4th, 1995, Oradea, Romania.

Čižmár,A.: Channel Equalization Using MLP. Proc. of "Digital Signal Processing and Telecommunications" at Seminar in Oradea, Romania, Nov. 23-25th, 1995.

Čižmár,A.: International Scientific Cooperation and Industry Cooperation of Universities as a Mean for Promotion of Slovak Economy. Conf. "Slovensko v siločiarach Európy a sveta na prahu 3. tisícročia.", Bratislava, Slovakia, October 10-12th, 1995. (in Slovak)

Thesis

Klenovičová Z.: Postupný prenos obrazov s využitím obrazovej hierarchie. (Progressive image transmission by using image hierarchy.) Ph.D. Thesis, FEI TU Košice, Slovakia, Oct. 1995.

Other Publications

Čižmár,A.: Transmission Line Equalization Using MLP's. COST 249 - Continuos Speech Recognition Over the Telephone: Minutes of the 3rd MCM in Nancy, France, March 6-7th, 1995.

Čižmár,A.: International Project Activities of Faculty of Electrical Engineering and Informatics. Workshop of ACTS Programme, Oct. 30-31st, 1995, Budapest, Hungary.

Čižmár,A.-Levický,D.-Juhár,J.: Present Network Characteristics in Košice. Report for COPERNICUS 587 technical audit in Brussels. Košice, Krakow, Nancy, September 1995.

4.2. Laboratory of Digital Signal Processing and Satellite Communications

Staff

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Ing.Peter Balco (distance form)
Ing.Ľudmila Maceková (distance form)

Research activities:

Research project No. 41141
Digital Methods for Signal Preprocessing and Transmission

Research project No. 2312/95
Intelligence Signal Processing in Telecommunications
Supervised by Prof. Ing. Dušan Levický, CSc.

Design and Implementation of Neural Filters for Image Processing

Scientific staff: S. Marchevský, M. Drutarovský, Ľ. Doboš, Ľ. Maceková, J. Raček, V. Segeďa

The purpose of the project is to develop efficient algorithms for the design and implementation of nonlinear adaptive filters based on neural networks.

A new fast generalized design algorithm for neural weighted order statistic filters (NWOSF) based on minimization of k-th power error criterion is derived. This algorithm is almost the same as the back propagation algorithm used in neural networks that the positivity of the weights of NWOSF is imposed.

A new method of iterative filtration by using a classifier based on local image statistic is introduced. Iterative filtration allows significant improvement noise suppression.

Experimental results from monochrome and color image enhancement were provided to illustrate the performance of NWOSF.

Hybrid realization of SF (HRSF) was proposed. In HRSF, the signal processing is performed on the border between the analog and the digital worlds, where a set of analog signals is used as inputs, and digital data are obtained as the output. The problem of large array of A/D converters can be avoided. The realization is very effective when the input signals come from a sensor array (e.g. CCD image sensor), and which be integrated on the same chip as the hybrid SF. Another interesting application of HRSF is that the combination of sensor array and proposed hybrid realization of SF can be

used as the A/D converter with high noise immunity to impulsive noise, and complete filtration is performed by analog hardware.

The architecture of neural stack filters for vector valued signals was proposed. They use additional information about the signals in different components of vector valued signals. Experimental color television signal RGB results from image enhancement of corresponded by impulsive noise and comparison with vector median filters and with component wise filtering by weighted order statistics filters were presented.

Pitch Detection Algorithms for Speech and Audio.

Scientific staff: J.Juhár

Speech and audio signals consists of alternating periodic and aperiodic intervals. Periodic of voiced intervals are characterized by waveform patterns called pitch periods, associated with the activity of the vocal cords. A pitch period is the waveform interval between successive glottal pulses in voiced portions of speech. The location of a sequence of pitch periods in the waveform is called pitch tracking and represents an important part of many speech processing systems. The pitch contour of an utterance is useful for recognizing speakers, for speech instruction to the hearing impaired and is required in almost all speech analysis-synthesis systems.

Because of the importance of pitch detection, a wide variety of algorithms for pitch detection and tracking have been proposed. Our research in this field has been devoted to comparative performance study of various pitch detection algorithms. Our goal in the following period is studying new detection algorithms based on some modern signal analysis methods such as wavelet transform, time-frequency distributions (e.g. Wigner-Ville) and neural networks as well as their real-time implementation with DSP's.

Nonlinear Digital Filters

Scientific staff: D.Kocur

Digital filtering belongs to basic methods of digital signal processing. It has found a number of applications in the various fields of human activities. It may be supposed that in the future the spectrum of digital filtering applications will be remarkably extended.

One of the actual trends of the research in the field of digital filtering methods is represented by nonlinear digital filtering studying. The interest in nonlinear filtering results from knowledge that under condition of non-Gaussian signal processing or in the case of nonlinear system modeling a filter which is optimum for the solution of these tasks, is some nonlinear filter. It means that the applications of nonlinear filters can provide the higher quality of signal processing than corresponding linear filter applications. This property of the nonlinear filters has presented the reach source of a motivation for the research in the field of nonlinear filters.

Our research in the field of nonlinear filtering has been intent on nonlinear Volterra filters (VF), nonlinear microstatistic Volterra filters (MVF), nonlinear filters with canonical piecewise-linear structure (PWLF) as well as on tree-structured piecewise-linear adaptive filters (TPWLF).

The VFs belong to a group of nonlinear estimators and they are based on the approximation of nonlinear functionals by a truncated Volterra series. Within our research in the field of Volterra filtering we have focused on the problems of adaptive algorithms of adaptive VFs. Here, a new approach to classification of at the present time known adaptive algorithms of adaptive VFs was proposed. The review of the known adaptive algorithms was also prepared including the review of basic properties of the particular algorithms. In this review, the properties of many algorithms have been demonstrated by using conveniently selected computer experiments.

In the field of adaptive VFs also a new adaptive algorithm based on conjugate gradient method has been developed.

In the field of a design of new categories of unconventional nonlinear filters we have proposed a new class of nonlinear filters so-called time-invariant MVF. This class of nonlinear filters is based on the idea of the conventional microstatistic filters (CMF) generalization by substituting Wiener filters (WF) applied in the CMF structure by the VFs. The advantage of the MVF in comparison with the WF, VF and CMF is the fact that in the case of non-Gaussian signal processing the MVF can outperform WF, VF or CMF. On the other hand, the disadvantage of the MVFs is their substantially higher computational complexity. With regard to the two very important facts it can be said that the MVF can be applied with advantage in this field of signal estimation where the applications of the WF, VF or CMV cannot provide the desired quality of signal processing.

In the field of unconventional nonlinear adaptive filters we have focused our effort on the PWLFs and TPWLFs. Here, based on the available references, we have started to study basic properties of these two kinds of nonlinear adaptive filters.

International Cooperation

Innovative Methods of Noise and Vibration Analysis on Reciprocating Machinery for the Purpose of Quality Control and Diagnostics.

Supervisor: Doc. Ing. Dušan Kocur, CSc.
Scientific staff: M. Drutarovský, P. Galajda, S. Marchevský, E. Matúš

Partners: MEDAV Digitale Signalverarbeitung GmbH, Germany
Technical University Ilmenau, Germany
Technical University Liberec, Czech Republic
LIAZ a.s. Jablonec n. Nisou, Czech Republic
ŠKODA a.s., Czech Republic
Technical Testing Institute Piešťany, Slovak Republic
Technical University Budapest, Hungary

This project represents an applied research in the field of noise and vibration analysis on reciprocating machinery. The intended measurement methods should improve the conditions for the development of new low noise and vibration products in the area of machine tools, machinery, and automobile industry. The methods should also contribute to improvement of safety, reliability, and maintainability of the new products.

The theoretical base of the project are modern methods of digital signal processing (DSP), statistic signal analysis, system identification and signal classification using neural nets. The implementation of the algorithms is founded on a modular DSP-based systems.

The effort of our research and development group has been focused on the implementation of selected digital signal processing algorithms on digital signal processor DSP56001/2, as well as on the applications of wavelet transformation, higher-order spectra and psychoacoustic methods for the purpose of extraction of meaningful features of signals to be analyzed.

Member

Ing. Jozef Juhár, CSc., Member of the Audio Engineering Society, New York, I.D. 44164

Ing. Jozef Juhár, CSc., Member of Technical Standardization Commission No.55 for Electroacoustics and ultrasound in Slovakia.

PUBLICATIONS

Journal Papers

Drutarovský,M.-Marchevský,S.: The Methods of Design and Implementation of Stack Filters. Radioengineering Vol. 4, No. 1, April 1995, pp.13-17.

Vaško,J.-Kocur, D.: Fast Tracking RLS Adaptation Algorithms of the Second-Order Volterra Digital Filters. Radioengineering, 1995, Vol.4, No.1., 22-27.

Kocur,D.- Drutarovský, M. - Marchevský, S.: A New Class of Nonlinear Filters: Microstatistic Volterra Filters. Accepted for publication in Radioengineering.

Levický,D. - Drutarovský,M. - Galajda,P. - Kocur,D. - Marchevský,S.: Adaptive Goertzel's Algorithm for DFT Computation with Higher Accuracy. Accepted for publication in Radioengineering.

Conference Papers

Marchevský,S.: The design 1D and 2D FIR Filters Using Window Functions. Proc. of Workshop "Digital Signal Processing and Communications", Oradea, Nov. 23-25th, 1995, pp.33-42.

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Other Publications

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Levický, D. - Marchevský, S. - Kocur, D. - Drutarovský, M. - Galajda, P.: Harmonický analyzátor sieťového napätia HARAN 30-1, popis technického riešenia (Power Voltage Harmonic Analyzer HARAN 30-1, technical description), research report HZ 16/93, Košice, Jan. 1995. (in Slovak)

Drutarovský, M.: C-Programming for DSP56001 Part of miniSYS. Proc. of the 3rd COPERNICUS Workshop of Innovative Methods of Noise and Vibration Analysis on Rotating Machinery for Purpose of Quality Control, Monitoring and Diagnostics, Ilmenau, Germany, Sept. 1995, pp.1-8.

4.3. Laboratory of Digital Image Processing and Communication

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Research activities:

Digital Coding and Transmission of Images in Videotelephone and Videoconference Systems

Grant research project No.1707/94
Supervised by Doc.Ing. Ján Mihalík, CSc.
Scientific staff: J.Zavacký, I.Gladišová, R.Labovský, I.Kuba, J.Dzivý, M. Dulina

Efficient image coding reduces a bit rate at the same quality of coded images and so there may be a decrease in channel capacity for transmission or storage for record of digital images. The high data compression, complexity

of hardware and noise immunity are important characteristics for a choice of efficient coding methods. At present, the well - known ones are prediction, transform and hybrid methods of image coding. The hybrid image coding is a combination of the transform and prediction ones. Its different modifications are divided from the modifications of the transform and prediction ones. Our research in regard to CCITT International standardization of image codecs for their application into videotelephone and videoconference systems is orientated above all to hybrid codecs with two dimensional DCT, vector quantization and interframe prediction by using motion compensation.

In the area of vector quantization we make research towards suboptimal vector quantizers, because the optimal (full search) one has a large computational complexity, which grows exponentially with dimension. The suboptimal vector quantizers with a structural code-book achieve lower performance compared to the full search on of the same dimension and bit rate. They can achieve higher performance one that of the full search for the same computational complexity, because they may have bigger dimensions at the same bit rate. The suboptimal ones are: the tree search, geometrical, contour - gain, multistage and hierarchical vector quantizers, which can be realized as fixed or adaptive ones.

The interframe prediction of videotelephone or videoconference images with high performance is carried out by using motion compensation. Our research of the motion estimation is orientated to words the difference methods by using the recursive or nonrecursive algorithms next to the correlation methods from which are known iterative, logarithmic and hierarchical ones.

The image spectrum is anizotropic therefore the efficient discrete representation of an image may be obtained by multidimensional sampling in general by nonorthogonal lattice. The spline interpolators can carry out interpolation of the decoded images with high accuracy at low sampling

frequency. In this area we concentrate towards searching for the optimal spline functions from the point of view precision as the advantageous technical realization and to the developing of hardware of spline interpolators on the basis of VLSI technology.

Digital Image Processing in Videocodecs

Institutional research project No.42143
Supervised by Doc.Ing. Ján Mihalík, CSc.
Scientific staff: J.Zavacký, I.Gladišová, R.Labovský, I.Kuba, J.Dzivý, M. Dulina

The specific methods of digital image processing in videocodecs increase the performance of coding and data compression. Our research in the area involves the statistical and structural analysis in the image space and transform domain. Multiresolution decomposition of images by using the bank of mirror filters and the wavelet transform. Next, the block matching and recursive methods of motion estimation and compensation in images on the basis of the hierarchical or Kalman algorithms. Finally, nonlinear interpolation and prediction of images by the spline functions and the neural networks. The results of the research are applied at the vector quantization, prediction, transform, hybrid and subband coding of images.

PUBLICATIONS

Journal Papers

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Kuba,I.: Interpolačné vektorové kvantovanie obrazu. (Interpolative Vector Quantization of Image.) Rigorous Work, FEI TU Košice, Slovakia, June 1995.

Labovský,R.: Pamäťové vektorové kvantizátory. (Memory Vector Quantizers.) Rigorous Work, FEI TU Košice, Slovakia, July 1995.

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Ing. Július Tomčík (distance form)

Research activities:

Multidimensional digital signal processing and transmission

Fiber Optics

Simulation of Fibre Optic Communication and Sensory Systems
Financial support: Institutional grant project No.42144, FEI TU Košice
COST 229 Application of Digital Signal Processing to Communications
COPERNICUS 1529 Development of Teleworking and Multimedia Services over High Speed Digital Networks
Supervised by Prof.RNDr.Ing. J. Turán, DrSc.
Scientific staff: Ľ.Ovseník, M.Mihok, O.Tkáč, J.Tomčík, R.Probstner

Wavelength division multiplexing in optical fiber sensor and communication systems

Combining the sensing and signal transmitting (i.e. telemetry) capability of optical fibers provide the strongest driving force for fiber optic sensor network development in the coming years. This capability becomes increasingly attractive as fiber optical local area networks (LANs) are likely to be implemented in factories, buildings, offshore platforms and mobile systems.

In a sensor network, at least two sensors, which may be discretely or continuously distributed in space according to a suitable topological pattern (linear array, star, ladder, ring), are operated and controlled by a single central optoelectronic terminal or transceiver unit. This requires a scheme to provide unambiguous sensor addressing (or multiplexing) and interrogation (or demodulation). We will deal only with networks of sensors having spatial distribution that is discrete or quantized, i.e. point sensors. The intrinsic or extrinsic sources of optical information regarding the non-optical measurand, and this information may be carried by the amplitude (intensity), phase, polarization, or spectral distribution of the optical carrier. In addition, the sensor information may be encoded in the frequency or time domain by means of the phase of an envelope modulation of the light.

The topology of a fiber optic sensor network is strongly determined by the desired method of sensor modulation and interrogation. The interrogation may be performed in the time (TDM), frequency (FDM), or wavelength domain (WDM). The WDM technique is feature unique to optical sensors, whereas the others are used for addressing conventional electrical sensors.

Wavelength division multiplexing offers a potentially powerful technique for use with in optical fibre sensor and communication systems. The work deals with short review of this technique with reference to systems of discrete optical fibre sensors. Potential network topologies for wavelength division multiplexing multiple sensor networks are analyzed, with description of their major features and implementation constraints. The program code for CAD system for WDM fiber optic sensor system projecting will be developed.

Fiber optics application in the microwave domain

The optical transmission and distribution of high speed, high frequency signals is among the fastest growing technologies in telecommunications. On the long term, there is the possibility of monolithic integration of optical and microwave components to produce self-contained devices and subsystems performing functions in communications, computer networks, process control, test procedures, and other areas. In the near future, hybrid microwave optoelectronic components presumably will lead to new applications such as low cost broad band distribution networks of high definition television signals (HDTV), high speed chip to chip optical inter-connects, microwave - optical links in commercial interconnects, microwave - optical links in commercial satellites, high speed subcarrier multiplexed optical local area networks and numerous other applications which cannot be achieved with present technologies. key, to these developments is the high speed optoelectronics. As a rapidly expanding and maturing area, optoelectronics has many potential applications in the near future.

For enhanced transmission capacities there is an increasing interest in the interfaces of microwaves and lightwaves. This interest has been generated partially by the availability of new, high speed, electrooptic devices (diode lasers, modulators, switches, etc.) and partially by the development of more sophisticated microwave and millimeter wave circuits and system.

There is a strong trend to apply more and more monolithic microwave - photonic integrated circuits for communications. In the fields of optical transmission and distribution of high speed signals new modulation and detection methods are introduced. The recently developed low noise optical amplifiers extend the application field of the optical transmission of high speed, high frequency signals.

Optically powered sensor telemetry system

Optically powered sensor telemetry systems include advantages of electrical as well as fiber - optic sensors. The applications of the system include aerospace, aircraft, automobile instrumentation, process control, industry and medical test instruments, etc. The system is created by optical and electrical parts. The optical part is used for the transmission of energy to electrical sensor itself, i.e. for electrical sensor powering, as well as for transmission of the information from the sensor to the processing unit. The electrical part is composed of the coding circuit and the optical pulse transmitter. The main part of the coding circuit is the resistance-dependent generator. Signal from the generator is converted to series of pulses. The time distance between two pulses corresponds to the sensed quantity. The restrictions for the electrical parts are the minimum possible current consumption and very small supply voltage: A very important role plays the opto-electrical converter and the laser source used for feeding the system. A single optically powered sensor telemetry system can by simply extended to the optically powered sensor network.

High speed optical communication system

Many commercial, scientific and educational environments face the communications bottleneck resulting from the limited transmission speed of to days interconnect technologies. Medical centers and hospitals would be able to transmit images form magnetic resonance scans to hundreds of work stations simultaneously. Universities, research centers and large corporations all need to link their mainframes, minicomputers, work stations and PC, to highs speed networks over campuses. In other areas, users do not need to share computing power, but they do need access to central mass storage in the form of large, redundant disk arrays. Potential network architectures are analyzed with the applications in multimedia communications electrical power industry and digital image transmission.

Hough and rapid transform

Transform Methods for Digital Multidimensional Signal Processing

Financial support :Grant project No. GAV 1680/94-9431 Ministry of Education and Science Slovak Republic, Bratislava

COST 229 Application of Digital Signal Processing to Communications

COPERNICUS 1529 Development of Teleworking and Multimedia Services over High Speed Digital Networks

Supervised by Prof.RNDr.Ing.J. Turán, DrSc.

Scientific staff: M. Chudáčik, J.Gamec, J.Futő, J.Kövesi, M.Kövesi, M.Jacko, Z.Štiblár

Hough transform

Hough transform (HT) is an universal method of detecting parametric curves, non-parametric curves of other objects in noisy pictures. It is used in picture information processing in robotics, scene analysis, medical science, industry, military technology, etc. Through the detection properties of HT have been analyzed from different points of view, it is necessary to study the HT representation properties in connection with methodology

of using HT spectral region, based on the new results of digital or analog signal processing theory. The major problem with practical application of HT in industry is the need of fast, reliable and economic HT processor (HTP). The current HTP perform the computation of HT spectrum in the electrical or optical area. A disadvantage of electronic digital HTP is that it is necessary to implement a great number of multiplications and additions which usually results in the low speed of computation and increasing the complexity of device. Though the current optical HTP make it possible to speed up the HT spectrum computation, they require spatial, very exacting, and thus also very expensive optical components. They are also very sensitive to the surrounding effects due to the volume optics components used. Diversification in HT applications shows its remarkable adaptability in solving new picture processing problems.

Based on the our new inventions this will be a development and implementation of new electronic fast HTP, working in real time in on-line with previous development our original Digital Image Preprocessing System (CSPO-III). We also continue further evaluation of use of HT for feature extraction in pattern recognition with study of new methods of HT spectral domain processing.

Rapid transform and its inversion

Rapid transform (RT) and others fast translation invariant transforms (CT) are very attractive for many digital image classifications problems. They belong to a special class of non-linear transforms with a fast computing graph. As a consequence the transforms have a very simple and fast hardware realization. Although the RT is a non-linear and thus non-invertible, adding to the RT transform process a binary coding process (t.e. computing so called coding matrix (CM))one may obtain the original signal (one, or two-dimensional) from its RT spectrum coefficients.

Our research group has a long time, more than 10 years, history of research into RT or CT. We discovered RT-l, new fast translation invariant transform NT and new methods for they evaluation, computation and theoretical analysis. We have one patent on a very fast RT processor (RTP). It is intended that the result of this study will be new methods of effective signal (picture) coding and the use of RT and RT -l in image sequence coding.

In TV picture sequence there is a high degree of correlation between successive frames, and interframe coding makes use of the redundancy to reduce the information to be transmitted. The motion compensation can be used to overcome the difficulty of significant movement. For motion estimation will be studied the application of RT-l and other transform methods.

New 3D object recognition system studied in this project is based on the analysis of acoustic waves reflected by the objects. The reflected signals are analyzed in the time - invariant RT transform domain and compared wit reference patterns stored in memory. The application of fast shift - invariant RT in signal classification increase the capability of the system to distinguish and identify different objects.

International cooperation

Project: **"Crowd Evaluation by Digital Image Processing"**
King's College, University of London, UK
TU Budapest, Dept. of Microwave telecommunication, Hungary
COST 229, COPERNICUS 1529
University of Ljubljana, Dept. of Electrical and Computer Eng., Slovenia
COPERNICUS 1529
University of Delft, Dept. of Electrical Eng., Laboratory for Telecommunications and Image Processing, Netherlands
COST 229, COPERNICUS 1529
Technical University of Cluj-Napoca, Dept. of Electrical Eng., Romania
COST 229, COPERNICUS 1529
University of Firenze, Dept. of Electrical Eng., Italy
COST 229, COPERNICUS 1529
University of Gent, Dept. of Telecommunications and Information

Technologies, Belgium, COPERNICUS 1529

PUBLICATIONS

Journal Papers

Turán,J.- Althöfer,K.: A Novel System for 3D Acoustic Object Recognition Based on the Modified Rapid Transform. Journal of Electrical Engineering, Vol. 46, No. 8, 1995, pp. 265-269.

Conference Papers

Turán,J.-Davies,A.C.-Velastin,S.: Crowd Motion Detection Using Inverse Rapid Transform. Proc of 2nd Int. Conf. on Image and Signal Processing, Budapest, Nov. 8-10th, 1995, 73-75.

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Althöfer,K.-Fraser,D.A.-Bugmann,G.-Turán,J.: The Configuration Space Transformation for Articulated Manipulators: A Novel Approach Based on RBF-Networks. Proc. of the 4th Int. Conf. on Artificial Neural Networks, IEE, Cambridge, UK, June 16-18th, 1995, pp.245-249.

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Turán,J.-Probstner,R.: Projecting and Modeling WDM Fiber Optic Sensor Networks. Workshop CAD&CAE '95, Prague, Czechia, Nov. 30th, 1995, pp.81-86.

Theses

Chudáčik,M.: Houghova transformácia a jej inverzia v číslicovom spracovaní harmonických signálov. (Hough Transform and its Inversion in Digital Processing of Harmonic Signals), Ph.D. Thesis, FEI TU Košice, Slovakia, May 1995.

Gamec,J.: Použitie Rapid transformácie pri estimácii pohybu. (Using of Rapid Transform in Motion Estimation), Ph.D. Thesis, FEI TU Košice, Slovakia, June 1995.

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Research activities:

Neural networks and fuzzy logical structures for intelligent instrumentation.

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Co-laborating part time scientific staff:
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J.Pivka, University of California, Berkeley, USA,

T.Frič, TU Delft, Netherlands.

Artificial neural networks in instrumentation

The neural circuits represent a contemporary system of the parallel working processors with the ability to solve complex constrained optimization problems. The programming of neural networks is based on the training procedure in which the structure and the connection parameters are modified through experience represented by training set. Hardware implemented neural networks are perspective components for fast pattern recognition tasks in the instrumentation (analog-to-digital conversion, quantization of the measured analogue, time limited output signals into final number of the discrete classes) and the signal processing in the conditioning circuit of a measuring chain. The studied Tank-Hopfield neural structure enable to find the best fitting estimation of the finite time input pulse by the combination of the basic functions. The network output are the binary values determining the presence or absence of single base components. The orthogonality of the base function is not necessary.

A new neural circuits design approach was developed in framework of scientific co-operation with the research partners abroad. This approach utilizes a transformation of functional block scheme into a structure of sub-sets containing connection of the neurons. The nextgoing circuit optimization allows to create final perceptron with minimal number of neurons.

The theoretical conclusions are being experimental verified on the commercialized component ETANN (Electrically Trainable Analog Neural Network) i 18070 NX by Intel at the partner's University of Calabria in Rende (CS), Italy. This circuit contains 64 neurons and it suit well for signal decision tasks in measurement.

The deeper study of the neural network mathematical model is focused on the main aim to suppress a presence of the "spurious states" created by local minima. Software simulation of designed neural structure is a sophisti-

cated tool for the estimation of parameters expected. Both models allow to predict metrological parameters of the processing procedure in statical and dynamical mode.

Intelligent measurement

The digital methods of systematic error correction in the processing circuits of intelligent measuring systems is another research objective of this scientific group. The main topic in this objective is focused on the application of standard and nonstandard interfaces, plug-in boards and analog-to-digital converters. In the framework of this tasks the methods of A/D converters testing with using the FFT of the harmonic test signal are being studied. The obtained outcomes are utilized for the software driver design in the LabWindows environment.

Statistical sensors

The statistical sensor has been the next component which measured information is represented by the probability of the one binary state occurrence in the output signal. Its advantage is small dimension, sensitivity on the wide scale of the physical quantities and possibility to create the field from these sensors. The simple principle of an information conversion and transmission designate this sensors for the application in the intelligent sensors. There is possible to realize diagnostic and autocalibration very simple. That is a necessary condition for the special applications in the sensing of the nonelectrical quantities with high grade of the reliability (nuclear energetic and traffic systems).

Multilevel memory elements

The multilevel memory cell has been another component of the fuzzy logic structure. The goal of the study of its dynamic behavior is to find out the influence of the control pulse parameters on the memory cell ability to rewrite

or damage the written information. The response of the multilevel memory cell on the control pulse has been advantageous to study using a computer simulation. The present state of the computer technology enables us to suppose the computer simulation to be equivalent of the physical verification. This is especially advantageous in the cases when the studied cell is a part of the integrated circuits structure with tiny geometrically dimensions.

International cooperation

TEMPUS Project: **Information Systems in Industry**
Project No. S_JEP-09484-95
Supervisor: Prof. Ing. Karol Florian, DrSc.
Scientific staff: L. Michaeli, J. Šaliga, and members of various departments from all faculties of TU.

Partners: Universita di Salerno, Facolta di Ingegneria, Italy
University of Calabria, Faculty of Engineering, Italy
The Nottingham Trent University, Dept. of Electrical and Electronic Engineering, UK
Fachhochschule Ulm, Fachbereich Automatisierungtechnik, Germany
University of Transport and Communication, Institute of Industrial Engineering, Žilina, Slovakia
VSŽ Košice, Research and Testing Institute, Slovakia
Electronic Control Systems, Ltd., Bratislava, Slovakia
Transtech Parallel Systems, Ltd., High Wycombe, UK.

The project complies with objective - I of TEMPUS priorities for Slovak Republic: Development of integrated and interdisciplinary studies with emphasis upon compatibility and equivalence with EU universities in a priority subject area of information and telecommunication technology.

The project will develop a curriculum for a new major speciality area - in industrial engineering - based upon the theory and practice of information technologies. The curriculum affords essential education to those who have an aptitude for engineering and a potentional capacity for management. The program is planed to prepare students for careers in industrial production

operations in which automatization and current programming methods are being applied completely or in a part.

Research area:**Hardware implementation of neural-based A/D converters**

Prof. Linus Michaeli, Invitation as a visiting professor, Dept. of Electronics, Informatics and Computer Science, Univ. of Calabria, Rende(CS), Italy, 15 weeks.

Ph.D. students exchange:

A.Molinaro, Univ.of Calabria, short term stay at the Dept. of Radioelectronics, TU Košice, Slovakia,

T.Frič, Ph.D.Study at the TU Delft, Netherlands.

The scientific co-operation is supported by means of common prepared project in the framework "TEMPUS" project JEP .

Research area: **Chaos in Nonlinear Circuits**
Long-term study stay: **L. Pivka**, Cal Tech, Berkeley, California, USA, Dept. of Electronics and Computer Science.

Member

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Šaliga Ján , Member of Slovak IMEKO Technical Committee TC-4 "Measurement of Electrical Quantities".

Michaeli Linus, Member of Technical Standardization Commission No. 55 for Electroacoustics and Ultrasound in Slovakia.

Michaeli Linus, Slovak Metrological Institute, Member of the Scientific Board.

PUBLICATIONS

Journal Papers

Daponte,P.-Grimaldi,D.-Michaeli,L.: Gray Code ADC Based on an Analogue Neural Circuit. Submitted for publication in Radioengineering, No.1./95

Michaeli,L.-Somora,M.-Kalakaj,P.-Šak,P.:Auswertesystem für Mechanische Deformation. (Preprocessing System for the Mechanical Forces

Instrumentation.) In the monography "Multisensorik Praxis", Editor Dr.-Ing.habil.H.Ahlers, Springer Verlag Berlin, 1995.

Šaliga,J.-Levický,D.: Systémy automatizovaného merania, zberu a spracovania dát. (Automatic Systems for Measurement, Data Acquisition and Proces-sing), ISSN 1335-0048, Technická Revue 1/95, pp.14-15. (in Slovak)

Špány,V. - Guzan,M. - Kalakaj,P. - Levický,D. - Pivka,L. - Šak,A.: Štatistický senzor - novinka senzoriky (Statistical sensor - a new component in sensoric), ISSN 1335-0048, Technická Revue 3/95, pp.14-16. (in Slovak)

Conference Papers

Daponte, P. - Grimaldi, D. - Michaeli,L.: A Full Gray Code Based ADC. Proc. of IMTC'95, Boston, USA, pp.795-801.

Caputo,L. - Grimaldi,D. - Michaeli,L. - Pugliese,L.: Non-linear Error Analysis for Neural A/D Converters, Proc. of IMEKO TC-4 Symp. "Modern Electrical and Magnetic Measurement", Prague, Czechia, Sept.1995, pp.160-164.

Michaeli,L.: Components for the Intelligent Signal Conditioning from the Smart Sensors. Proc. of MBB'95 "Model Based Biomeasurements", Stará Lesná, Slovakia, Sept.1995, pp.118-120.

Šaliga,J.: Hardware Support for Data Acquisition Systems. Proc.of MBB'95 "Model Based Biomeasurements", St. Lesná, Slovakia, Sept.1995,136-138.

Pivka,L.-Zeleznyak,A.L.-Chaiwah,W.-Chua,L.O.: Arnold's Tongues, Devil's Staircase and Self/Similarity in the Driven Chua's Circuit. Accepted for publication in the Int. Journal of Bifurcation and Chaos, 1995. Conf. Papers.

Levický,D. - Drutarovský, M. - Galajda, P. - Kocur, D. - Marchevský, S.: Adaptive Goertzel's Algorithm for Harmonic Analysis of Power Voltage. Proc. of the 40th Int. Wissenschaftliches Kolloquium, Ilmenau, FRG, Sept. 1995.

Theses

Šaliga,J.: Digital Methods for particle Identification in the Scintillation Detectors. Ph.D. Thesis, FEI TU Košice, June 1995.

Galajda,P.: Analýza viachodnotovej pamäťovej bunky. (Analysis of the multilevel memory cell), Ph.D. Thesis, FEI TU Košice 1995.

5. FACULTY ESSAYS

Chudáčik Milan

Assistant professor

His research interests are in digital signal and image processing, Hough transform and Hough transform processors.

Čižmár Anton

Associated professor

His research interests include speech processing, neural networks, data compression and digital communications.

Doboš Ľubomír

Assistant professor

His current interests are in the linear adaptive digital filters, least Mean Square algorithms and QR decomposition.

Drutarovský Miloš

Assistant professor

His research interests include neural networks, nonlinear digital filters for image processing, digital signal processors and microcontrollers.

Galajda Pavol

Assistant professor

His present fields of interest are multiple - valued logic systems and its application, VLSI multiple - valued memory design and smart sensors, dynamic properties of a multiple-valued sequential circuit.

Gamec Ján

Assistant professor

His general research interests include digital signal processing, block - matching algorithm and motion estimation.

Gladišová Iveta

Assistant professor

Her research interests are in the digital signal processing, geometric source coding and vector quantization, an algorithm for lattice and pyramid quantizers and codes.

Juhár Jozef

Assistant professor

His research interests are in the application of various signal processing methods in pitch detection and tracking algorithms for speech and audio.

Klenovičová Zita
Assistant professor
Her research interests include digital circuits and digital picture processing.

Kocur Dušan
Associated professor
His research interest is in digital signal processing, especially in linear and nonlinear time-invariant and adaptive digital filters, higher-order spectra and psychoacoustics.

Levický Dušan
Full professor
His main interests and activities are in the digital signal processing, microprocessors and picture processing and transmission.

Maceková Ľudmila
Assistant professor
Her general research interest includes design and implementation algorithms for two and three dimensional median filters for image processing.

Marchevský Stanislav
Associated professor
His main research interests are multidimensional digital filters, linear and non-linear digital filters for image processing.

Matúš Emil
Assistant professor
His research interest include digital picture processing.

Michaeli Linus
Full professor
His research interests are in the preprocessing systems in the instrumentation, simulation of the AD converters and modeling of their systematic error models.

Mihalík Ján
Associated professor
His current research interest includes signal and information theory, digital image processing (including effective coding, restoration, enhancement and statistical filtering), digital image communication.

Ovseník Ľuboš
Research assistant
His general research interests include fiber optics, fiber optical sensors and the fiber optical application in the microwave domain.

Šaliga Ján
Assistant professor
His general research interests include neural networks in charge of an amplitude shape pulse detector, measurement instruments, system sand methods.

Špány Viktor
Full professor
His main interests and activities are in the non-linear circuits theory, smart sensors, flip-flop sensors, integrated functional blocks and statistical sensors.

Turán Ján
Full professor
His main interests and activities are in the digital signal processing, Hough transform, rapid transform, fiber optics and its applications in communications, sensing and signal processing.

Zavacký Jozef
Assistant professor
His current interest includes signal and information theory, sampling of the one-dimensional and multidimensional signals.

6. Ph.D. Programme

Name	Supervisor	Field
First year of study		
Ing.Gabriel Hanko	prof. Michaeli	ADC converter
Ing. Martin Dulina	doc. Mihalík	digital picture coding
Ing. Juraj Futó (dist. form)	prof. Turán	optical communication
Second year of study		
Ing.Frič Tomáš	prof.Michaeli	neural networks
Ing.Jacko Miroslav	prof.Turán	Hough transform, DIP
Ing.Kövesi Mikuláš	prof.Turán	Rapid transform, DIP
Ing.Raček Jozef	doc.Marchevský	Kalman's filters for DIP
Ing.Segeďa Viliam	doc.Marchevský	Stack filters,genetics algorithms
Ing. Maceková Ľudmila(dist.form)	doc.Marchevský	Weighted median filters for DIP
Third year of study		
Ing.Böhmann Peter	prof.Levický	picture sequence processing
Ing.Dzivý Jozef	doc.Mihalík	digital signal processing
Ing.Hámorský Jozef	doc.Čižmár	digital speech processing
Ing.Kövesi Ladislav	prof.Turán	rapid transform, DIP
Ing.Král Peter	prof.Levický	digital picture coding
Ing.Probstner Róbert	prof.Turán	fibre optical sensors
Ing.Šak Andrej	prof.Špány	small signal quantities measur.
Ing.Štiblár Zoltán (dist. form)	prof.Turán	Rapid transform
Ing.Oleg Tkáč (dist. form)	prof. Turán	optical communications
Fourth year of study		
Ing.Balco Peter	doc.Marchevský	digital filtration
Ing.Guzan Milan	prof.Špány	smart sensors
Ing.Chromek Peter (dist. form)	prof.Levický	mathematic morphology
Ing.Kalakaj Peter	prof.Špány	oscillator sensors
Ing.Kuba Igor	doc.Mihalík	digital image processing
Ing.Labovský Ladislav	doc.Mihalík	digital signal processing
Ing.Mihok Marián (dist. form)	prof.Turán	optically powered sensors
Ing. Emil Matúš (dist. form)	prof. Levický	Wavelet transform

7. OTHER ACTIVITIES

7.l. Conferences, Seminars and Meetings

Organization of the seminar **"The Methods of Digital Signal Processing in Telecommunication"** with international participation, May 22-27th, 1995.

Seminar and presentation of BURR-BROWN and VITROHM components with cooperation of Dept. of Radioelectronics, FEI TU Košice and S.O.S. Electronic, spol. s r.o. Košice, Slovakia.

7.2. Study tours

Ing. Jozef Hámorský
University Erlangen-Nürmberk, FRG

Ing. Peter Král
University Erlangen-Nürmberk, FRG

Doc. Ing. Anton Čižmár, CSc., Staying at Gent University (prof. Martens), Gent, Belgium, April 27-31st, 1995.

Prof.RNDr.Ing. Ján Turán, DrSc.
6 month visiting prof. stay at University of London, King's College, Dept. of El. Eng. supported by Masaryk research fellowship, October 1994 - March 1995.

Ing. Miloš Drutarovský, CSc.
3 weeks working stay at MEDAV Digitale Signalverarbeitung GmbH, Germany, July 16th - Aug. 5th, 1995, supported by COPERNICUS project CIPA-CT94-0220.

Ing. Miloš Drutarovský, CSc.
1 week working stay at the Dept. of Measurement and Instrumental Engineering, Technical University of Budapest, Hungary, Nov. 5-10th, 1995, supported by COPERNICUS project CIPA-CT94-0220.

7.3. Visitors and visits

Prof. Pach, Prof. Wajda, AGH Krakow, Dept. of Telecommunications, July 6-7th, 1995, COPERNICUS 587 meeting in Košice.

Prof. Comerlati, University in Nancy, June 21-22nd, 1995.

Prof. Leuca, University of Oradea, October 11-14th, 1995.

Claire Berthier, ISTASE Saint Etienne, France, Engineer training period, professors in charge D. Kocur, M. Drutarovský, March - July, 1995.

Olivier Chomat, ISTASE, Saint Etienne, France, Engineer training period, professors in charge S. Marchevský, March - July, 1995.

Doc. Ing. Stanislav Marchevský, CSc., Technical University of Csestochova, Poland, Faculty of Electrical Engineering. Invited lectures on the topic: Digital Filters for Image Processing, May 17-23rd, 1995.

Doc. Ing. Stanislav Marchevský, CSc., Technical University of Oradea, Romania, Faculty of Electrical Engineering. Invited lectures on the topic: Linear and Nonlinear Digital Filters, May 17-23rd, 1995.

Doc. Ing. Dušan Kocur, CSc., Technical University of Ilmenau, Germany, Sept. 17-23rd, 1995.

Doc. Ing. Dušan Kocur, CSc., Technical University of Oradea, Romania, Nov. 23-25th, 1995.

Prof. RNDr. Ing. Ján Turán, DrSc., University of Valencia, Technical University of Valencia, Valencia, Spain, May 5-25th, 1995, IMG-Tempus Grant.

Prof. RNDr. Ing. Ján Turán, DrSc., Delft University of Technology, COPERNICUS 1529 MCM Meeting, February 2nd - 6th, 1995.

Prof. RNDr. Ing. Ján Turán, DrSc., TU Budapest COPERNICUS 1529 MCM Meeting, Conf. on Image and Signal Processing. November 7-11th, 1995.

Doc. Ing. Anton Čižmár, CSc., The visit of some Austrian universities (Leoben, Gratz, Wien), January 23-26th, 1995.

Doc. Ing. Anton Čižmár, CSc., Participation on the 3rd MCM of COST 249 in Nancy, France, March 6-8th, 1995.

Doc. Ing. Anton Čižmár, CSc., Participation on the COPERNICUS 587 meeting in Nancy, France, May 17-19th, 1995.

Doc. Ing. Anton Čižmár, CSc., Participation on the COPERNICUS 587 meeting in Krakow, Poland, June 19-20th, 1995.

Doc. Ing. Anton Čižmár, CSc., Participation on the Workshop ACTS (Advanced Communication Technology Services) in Budapest, Hungary, October 30-31st, 1995.

Doc. Ing. Anton Čižmár, CSc., Participation on the COPERNICUS 587 meeting in Nancy, France, December 12-13th, 1995.

Doc. Ing. Anton Čižmár, CSc., Workshop and seminar "Digital Signal Processing and Communications" at Technical University in Oradea, Romania, November 23-25th, 1995.

Ing. Jozef Juhár, CSc., AES 98th Convention, February 25-28th, 1995, Paris, France.

7.4. External lectures

Courses given for technicians :

1. Introduction to microprocessors systems (5 days)
2. Application of microprocessors systems (5 days)
3. Programming of microprocessors systems (5 days)
4. Introduction to digital circuits (6 days)
5. Introduction to C language (5 days)
6. C language, advanced course (5 days)
7. Computer and MS DOS (5 days)
8. EXCEL 4.0 (5 days)

Courses given for engineers with technical education.

1. Fiber Distributed Data Interface (3 days)

8. PUBLICATION ACTIVITY OF THE DEPARTMENT

Journal Papers

Daponte,P.-Grimaldi,D.-Michaeli,L.: Gray Code ADC Based on an Analogue Neural Circuit. Submitted for publication in Radioengineering, No.1./95

Drutarovský,M.-Marchevský,S.: The Methods of Design and Implementation of Stack Filters. Radioengineering Vol. 4, No. 1, April 1995, pp.13-17.

Kocur, D. - Drutarovský, M. - Marchevský, S.: A New Class of Nonlinear Filters: Microstatistic Volterra Filters. Accepted for publication in Radioengineering.

Levický, D. - Král, P.: Neural Networks in Visual Pattern Image Coding. Neural Network World. Vol. 5, No. 2, pp. 163-169.

Levický, D. - Matúš, E. - Král, P.: A Two Layer Hybrid Image Coder. Radioengineering, Vol. 4, No. 1, April 1995, pp. 2-6.

Levický, D.: 25 Years of the Radioelectronics Education at the Technical University in Košice. Radioengineering. Vol. 4, No. 1, April 1995, pp. 1.

Levický,D. - Drutarovský,M. - Galajda,P. - Kocur,D. - Marchevský,S.: Adaptive Goertzel's Algorithm for DFT Computation with Higher Accuracy. Accepted for publication in Radioengineering.

Michaeli,L.-Somora,M.-Kalakaj,P.-Šak,P.:Auswertesystem für Mechanische Deformation. (Preprocessing System for the Mechanical Forces Instrumentation.) In the monography "Multisensorik Praxis", Editor Dr.-Ing.habil.H.Ahlers, Springer Verlag Berlin, 1995.

Mihalík,J.-Gladišová,I.: Weighted Pyramid Vector Quantizer. Journal of Electrical Engineering, Vol. 46, No. 2, 1995, pp. 46-50.

Mihalík,J.-Zavacký,J.-Kuba,I.: Spline Interpolation of Image. Radioengineering, Vol.4, No.1, 1995, pp. 18-21.

Mihalík,J.: Contour Based Scalar-Vector Quantizer. Journal of Elect. Engineering, Vol.46, No.4, 1995, pp. 121-125.

Šaliga,J.-Levický,D.: Systémy automatizovaného merania, zberu a spracovania dát. (Automatic Systems for Measurement, Data Acquisition and Proces-sing), ISSN 1335-0048, Technická Revue 1/95, pp.14-15. (in Slovak)

Špány,V. - Guzan,M. - Kalakaj,P. - Levický,D. - Pivka,L. - Šak,A.: Štatistický senzor - novinka senzoriky (Statistical sensor - a new component in sensoric), ISSN 1335-0048, Technická Revue 3/95, pp.14-16. (in Slovak)

Turán,J.- Althöfer,K.: A Novel System for 3D Acoustic Object Recognition Based on the Modified Rapid Transform. Journal of Electrical Engineering, Vol. 46, No. 8, 1995, pp. 265-269.

Vaško,J.-Kocur, D.: Fast Tracking RLS Adaptation Algorithms of the Second-Order Volterra Digital Filters. Radioengineering, 1995, Vol.4, No.1., pp.22-27.

Conference Papers

Althöfer,K.-Fraser,D.A.-Bugmann,G.-Turán,J.: The Configuration Space Transformation for Articulated Manipulators: A Novel Approach Based on RBF-Networks. Proc. of the 4th Int. Conf. on Artificial Neural Networks, IEE, Cambridge, UK, June 16-18th, 1995, pp.245-249.

Caputo,L. - Grimaldi,D. - Michaeli,L. - Pugliese,L.: Non-linear Error Analysis for Neural A/D Converters, Proc. of IMEKO TC-4 Symp. "Modern Electrical and Magnetic Measurement", Prague, Czechia, Sept.1995, pp.160-164.

Daponte, P. - Grimaldi, D. - Michaeli,L.: A Full Gray Code Based ADC. Proc. of IMTC'95, Boston, USA, pp.795-801.

Doboš,Ľ.-Juhár,J.: Implementácia adaptívnych číslicových filtrov signálovým procesorom. (The Implementation of Adaptive Digital Filters via Signal Processors.) Proc. of the 1st Int. Conf. on Telecommunication Technologies, Bratislava, Slovakia, May 31st - June 1st, 1995, pp. 50-54.

Drutarovský,M.-Marchevský,S.: The Methods of Design and Implementation of Stack Filters. Proc. of Workshop "Digital Signal Processing and Communications", Oradea, Nov. 23-25th, 1995, pp.43-54.

Čižmár,A.: Channel Equalization Using MLP. Proc. of "Digital Signal Processing and Telecommunications" at Seminar in Oradea, Romania, Nov. 23-25th, 1995.

Čižmár,A.: International Scientific Cooperation and Industry Cooperation of Universities as a Mean for Promotion of Slovak Economy. Conf. "Slovensko v siločiarach Európy a sveta na prahu 3. tisícročia.", Bratislava, Slovakia, October 10-12th, 1995. (in Slovak)

Čižmár,A.: The Use of Neural Nets for Channel Equalization without and with Decoding. Proc. of Int. Conf. "Telekomunikácie '95", May 31st - June 1st, 1995, Bratislava, Slovakia, pp. 101-105.

Hroncová,I.-Čižmár,A.: A Time-Consumption and Efficiency of Several Discrete Types of Transforms. Bulletin for Applied Mathematics 1064/95, May 5-7th, 1995, Budapest, Hungary.

Hroncová,I.-Čižmár,A.: Comparison of Time - Consumption and Efficiency of Several Types of Transforms for 1D DSP. Proc. of Int. Conf. "Telekomunikácie '95", May 31st - June 1st, 1995, Bratislava, Slovakia, pp. 187-192.

Hroncová,I.-Čižmár,A.: Efficiency of Digital Signal Processing by Different Types of Transforms. Proc. of EMES (Engineering of modern Electric Systems '95.) ISSN-1223-2106, June 2-4th, 1995, Oradea, Romania.

Juhár,J.-Doboš,Ľ.: Záznam signálov - súčasný stav a smery vývoja. (Signal Recording - Current State and Development Trends.) Proc. of the 1st Int. Conf. on Telecommunication Technologies, Bratislava, Slovakia, May 31st - June 1st, 1995, pp. 138-139.

Klenovičová, Z. - Levický, D.: Modifikované kódovanie bitových rovín Grayovými kódmi. (Modified Coding of bit planes using Gray Codes.) Proc. of the 1st. Int. Conf. on Telecommunication Technologies, Bratislava, 31.5.-1.6.1995, pp.72-73.

Kocur, D. - Drutarovský, M. - Marchevský, S.: Microstatistic Volterra Filters. Proceedings of the 40. Internationales Wissenschaftliches Kolloquium, Ilmenau, September 1995, Band 1, pp.376-381.

Levický, D.: Niektoré nové smery v kódovaní a prenose číslicových obrazov. (Some New Approaches in Image Coding and Transmission.) T.I.S. '95, 3rd Int. Conf. with Exhibition, Žilina, 13.6.-16.6.1995.

Levický, D.: Some New Approaches in Still Image Compression and Transmission. Proc. of the 1st. Int. Conf. on Telecommunication Technologies, Bratislava, 31.5.-1.6.1995, pp.193-198.

Levický,D. - Drutarovský,M. - Galajda,P. - Kocur,D. - Marchevský,S.:Adaptive Goertzel's Algorithm for DFT Computation with Higher Accuracy. Proc. of Workshop "Digital Signal Processing and Communications", Oradea, Nov. 23-25th, 1995, pp.55-62.

Levický,D. - Drutarovský, M. - Galajda, P. - Kocur, D. - Marchevský, S.: Adaptive Goertzel's Algorithm for Harmonic Analysis of Power Voltage. Proc. of the 40th Int. Wissenschaftliches Kolloquium, Ilmenau, FRG, Sept. 1995.

Levický,D. - Drutarovský, M. - Galajda, P. - Kocur, D. - Marchevský, S.: Adaptive Goertzel's Algorithm for Harmonic Power Voltage. 40.

Internationales. Wissenschaftliches Kolloqium 18.9.-21.9.1995, Ilmenau, pp. 473-478.

Marchevský, S. - Drutarovský, M. - Galajda, P. - Kocur, D.: Application of Digital Filters in Brain-Machine Apparatus. Proc. of Workshop "Digital Signal Processing and Communications", Oradea, Nov. 23-25th, 1995, pp.63-65.

Marchevský,S.: The design 1D and 2D FIR Filters Using Window Functions. Proc. of Workshop "Digital Signal Processing and Communications", Oradea, Nov. 23-25th, 1995, pp.33-42.

Matúš, E. - Levický, D.: A Method for Block Image Coding. Proc. of the 1st. Int. Conf. on Telecommunication Technologies, Bratislava, 31.5.-1.6.1995, pp.199-200.

Michaeli,L.: Components for the Intelligent Signal Conditioning from the Smart Sensors. Proc. of MBB'95 "Model Based Biomeasurements", Stará Lesná, Slovakia, Sept.1995, pp.118-120.

Mihalík,J.-Dzivý,J.-Zavacký,J.: Subpásmové kódovanie obrazu s vektorovým kvantovaním. (Subband Coding of Image by using Vector Quantization.) Proc. of Int. Scient. Conf. "Telecommunication 95", Bratislava, Slovakia, May 1995, pp. 136-137.

Mihalík,J.-Dzivý,J.: Systém analýzy a syntézy obrazu. (Analysis/Synthesis System of Image.) Proc. of Int. Scient. Conf. "Electro 95", Žilina, Slovakia, Feb. 1995.

Mihalík,J.-Gladišová,I.: Geometrický vektorový kvantizátor s inverzným stromovým rozkladom mriežky. (Geometric Vector Quantizer by Using Inverse Tree Decomposition of Lattice.) Proc. of Scient. Conf. "Radioelectronics 95", FEI VUT Brno, Czechia, Apr. 1995, pp. 311-314.

Mihalík,J.-Labovský,R.: Stavový vektorový kvantizátor. (State Vector Quantizer.) Proc. of Int. Scient. Conf. "Electro 95", Žilina, Slovakia, Feb. 1995.

Pivka,L.-Zeleznyak,A.L.-Chaiwah,W.-Chua,L.O.: Arnold's Tongues, Devil's Staircase and Self/Similarity in the Driven Chua's Circuit. Accepted for publication in the Int. Journal of Bifurcation and Chaos, 1995. Conf. Papers.

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Turán,J.-Althöfer,K.: Feature Extraction for 3D Acoustic Object Recognition via the Modified Rapid Transform. Proc. of 2nd Int. Conf. on Image and Signal Processing, Budapest, Nov. 8-10th, 1995, pp. 170-177.

Turán,J.-Davies,A.C.-Velastin,S.: Crowd Motion Detection Using Inverse Rapid Transform. Proc of 2nd Int. Conf. on Image and Signal Processing, Budapest, Nov. 8-10th, 1995, 73-75.

Turán,J.-Ovseník,Ľ.: The Optical Fiber Sensor for Reading High Frequency Magnetic Field. Konf.: Experimentálna mechanika a aplikovaná optika, N. mesto nad Váhom, Slovakia, October 10-11th, 1995, pp.29-34.

Turán,J.-Probstner,R.: Automatizácia projekcie WDM senzorových systémov. (Automatization of Projection of WDM sensory Systems.) Konf.: Experimentálna mechanika a aplikovaná optika, N. mesto nad Váhom, Slovakia, October 10-11th, 1995, pp.23-28.

Turán,J.-Probstner,R.: Projecting and Modeling WDM Fiber Optic Sensor Networks. Workshop CAD&CAE '95, Prague, Czechia, Nov. 30th, 1995, pp.81-86.

Theses

Chudáčik,M.: Houghova transformácia a jej inverzia v číslicovom spracovaní harmonických signálov. (Hough Transform and its Inversion in Digital Processing of Harmonic Signals), Ph.D. Thesis, FEI TU Košice, Slovakia, May 1995.

Drutarovský,M.: Vážené neurónové poriadkové štatistické filtre na báze dekompozičnej architektúry. (Weighted neural order statistic filters based on threshold decomposition). Ph.D. Thesis, FEI TU Košice, Slovakia, June 1995. (in Slovak)

Galajda,P.: Analýza viachodnotovej pamäťovej bunky. (Analysis of the multilevel memory cell), Ph.D. Thesis, TU Košice 1995.

Gamec,J.: Použitie Rapid transformácie pri estimácii pohybu. (Using of Rapid Transform in Motion Estimation), Ph.D. Thesis, FEI TU Košice, Slovakia, June 1995.

Gladišová,I.: Geometrické vektorové kvantizátory. (Geometric Vector Quantizers.) Ph.D. Thesis, FEI TU Košice, Slovakia, Sept. 1995.

Klenovičová Z.: Postupný prenos obrazov s využitím obrazovej hierarchie. (Progressive image transmission by using image hierarchy.) Ph.D. Thesis, FEI TU Košice, Slovakia, Oct. 1995.

Kocur, D.: Adaptive Algorithms of Adaptive Volterra Digital Filters. Habilitation Thesis, FEI TU Košice, Slovakia, Dec. 1995. (in Slovak).

Marchevský,S.: Neural Stack Filters for Image Processing. Habilitation Thesis, Dept. of Radioelectronics, FEI TU Košice, Feb. 1995. (In Slovak)

Šaliga,J.: Digital Methods for particle Identification in the Scintillation Detectors. Ph.D. Thesis, FEI TU Košice, June 1995.

Other Publications

Drutarovský, M.: C-Programming for DSP56001 Part of miniSYS. Proc. of the 3rd COPERNICUS Workshop of Innovative Methods of Noise and Vibration Analysis on Rotating Machinery for Purpose of Quality Control, Monitoring and Diagnostics, Ilmenau, Germany, Sept. 1995, pp.1-8.

Čižmár,A.-Levický,D.-Juhár,J.: Present Network Characteristics in Košice. Report for COPERNICUS 587 technical audit in Brussels. Košice, Krakow, Nancy, September 1995.

Čižmár,A.: International Project Activities of Faculty of Electrical Engineering and Informatics. Workshop of ACTS Programme, Oct. 30-31st, 1995, Budapest, Hungary.

Čižmár,A.: Transmission Line Equalization Using MLP's. COST 249 - Continuos Speech Recognition Over the Telephone: Minutes of the 3rd MCM in Nancy, France, March 6-7th, 1995.

Kocur, D.: Adaptive Volterra Filters: A Tutorial Review. Digital Signal Processing and Communications. Proc. of Workshop, Oradea, Romania, Nov. 23-25th, 1995, pp.1-32.

Kuba,I.: Interpolačné vektorové kvantovanie obrazu. (Interpolative Vector Quantization of Image.) Rigorous Work, FEI TU Košice, Slovakia, June 1995.

Labovský,R.: Pamäťové vektorové kvantizátory. (Memory Vector Quantizers.) Rigorous Work, FEI TU Košice, Slovakia, July 1995.

Levický, D. - Marchevský, S. - Kocur, D. - Drutarovský, M. - Galajda, P.: Harmonický analyzátor sieťového napätia HARAN 30-1, popis technického riešenia (Power Voltage Harmonic Analyzer HARAN 30-1, technical description), research report HZ 16/93, Košice, Jan. 1995. (in Slovak)

For further information :

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