Signal and Information Processing Laboratory

Prof. Dr. A. Lapidoth, Prof. Dr. H.-A. Loeliger, Dr. K. Heutschi

ANNUAL REPORT

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Research Period 2003

Teaching Period 2002/2003

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Editor:	B. Röösli

Foreword

We are gratefully looking back to another year in which we had the priviledge to participate in the great adventure of research. Again we learned much, and again there is unexplored territory ahead...

The year 2003 was marked by several events. In February, the Winter School on Coding and Information Theory was held in Ascona. Its organization was mainly (and most competently) handled by Prof. Lapidoth, Stefan Moser, Daniel Hösli, and Justin Dauwels. In September, we hosted the 2nd Analog Decoding Workshop, which was superbly organized by Matthias Frey and Patrick Merkli. Finally, the 2004 Zurich Seminar on Communications demanded an increasing amount of attention, especially by our system administrator, Max Dünki, and by our secretary, Mrs. Bernadette Röösli.

Two fresh Ph.D.s left us in 2003: Dieter Arnold and Qun Gao. We also welcomed one new Ph.D. student: Stephan Tinguely, who graduated at EPFL.

As a final present of 2003, both Prof. Lapidoth and myself were elected Fellows of the IEEE.

April 2004 Hans-Andrea Loeliger

Contents

1. Personnel

Professor for Information Theory:

Prof. Dr. Amos Lapidoth

Professor for Signal Processing:

Prof. Dr. Hans-Andrea Loeliger

Adjunct Lecturer:	**Dr. Kurt Heutschi**		
Secretaries:	**Mrs. Bernadette Röösli**		
	Mrs. Renate Agotai		
Technical Supervisor:	**Dr. Max Dünki**		
Research Assistants:	**Dieter Arnold**	Dipl.El.Eng.	left on 31.03.03
	Justin Dauwels	Dipl.Phys.Eng.	
	Matthias Frey	Dipl.El.Eng.	
	Qun Gao	Dipl.El.Eng.	left on 30.6.03
	Markus Hofbauer	Dipl.El.Eng.	
	Daniel Hösli	Dipl.El.Eng.	
	Volker Koch	Dipl.Eng.	
	Sascha Korl	Dipl.Eng.	
	Patrick Merkli	Dipl.Eng. Microtechn.EPF	
	Natalia Miliou	Dipl.El.Eng.	
	Stefan Moser	Dipl.El.Eng.	
	Maja Ostojic	Dipl.El.Eng.	
	Stephan Tinguely	Dipl.El.Eng.	since 1.10.03
Technical Staff:	**Francesco Amatore**		
	Thomas Schärer		
	Patrik Strebel	El.Eng.HTL	

Scholarship Recipient:

Jelena Stamenkovic	University of Nis, Nis Rep. of Serbia	16.10. – 31.12.03

Academic Guests: (see 6.1 for report of activities)

Benjamin Vigoda	MIT Media Lab, Cambridge, USA	23.04. - 28.04.03
Prof. A. Lindgren	The University of Rhode Island Kingston, USA	01.06. – 31.08.03

2. Teaching

2.1 Lectures

Sem.	Instructors	Title	ETH-No.
5th	Prof. H.-A. Loeliger	Stochastic Models and Signal Processing	35-101
8th	Prof. H.-A. Loeliger	Algebra, Codes, and Signal Processing	35-416
5/7th	Prof. A. Lapidoth	Applied Digital Information Theory I	35-417
6th	Prof. A. Lapidoth	Information Transfer	35-104
6/8th	Dr. A. Mittelholzer	Applied Digital Information Theory II	35-418
7th	M. Hofbauer und Dr. R. Kretzschmar	Adaptive Filters and Neuronal Networks	35-467
8th	Dr. H.P. Schmid	Analog Signal Processing and Filtering	35-468
7th	Dr. K. Heutschi	Acoustics I	35-477
8th	Dr. Heutschi	Acoustics II	35-478

2.2 Practica

5/ 6th	Practica	Laboratory for "Fundamentals in Electrical Engineering"	35-095/6
1st/2nd	D. Hösli	Cellular Automata	PPS
3rd/4th	V. Koch, S. Korl	Practical Signalprocessing using a DSP	PPS
2nd/3rd	Th. Schaerer	EMG Biofeedback Device	PPS
3rd/4th	P. Merkli, M. Frey	Probability Gates and Analog Decoding	PPS
3rd/4th	Prof. H.-A. Loeliger	Introduction to LaTeX	PPS

2.2 Semester Projects and Diploma Theses

During the winter semester 2002/03 and summer semester 2003, 6 Semester Projects (9 candidates) and 11 Diploma Theses (12 candidates) were carried out.

Candidates	Title	Supervisor
Semester Projects SS 2003 (8th Semester)		
Tobias Koch	Continuous-Time Synchronization	Frey Dauwels Merkli
Samuel Bruhin Benjamin Amsler	Decomposition of Superimposed EMG Signals	Koch
Michael Gutman	Mehrkanalige Verfahren zur Störgeräuschbefreiung in Hörgeräten II	Hofbauer Korl
Simon Schilling	Graphical Models für die Vorhersage extremer Wetterereignisse	Kretzschmar Dauwels
Yann Baud Etienne Auger	Speech Enhancement with Factor Graphs	Korl Hofbauer
Nicole Hediger Clive Diethelm	Discrete-Time Synchronisation	Merkli Frey
Diploma Theses WS 2002/03		
Roman Schilter	Mehrkanalige Verfahren zur Störbefreiung in Hörgeräten	Hofbauer Korl
Wolfgang Irnberger	Speech Enhacement with Factor Graphs	Korl Hofbauer
Markus Galli	Klassierung von Verkehrslärm	Lippuner Kälin Siemens AG
Siegfried Leimgruber	Vorhersage extremer Wetterereignisse: Anwendung neuronaler Netze und Informationstheorie	Kretzschmar
Michele Wigger	Bounds on the Capacity of Free-Space Optical Communication Channels	Moser
Franziska Pfisterer	Wind Noise Canceling for Hearing Instruments	Allegro/Phonak Korl
Katrin Kempin	Bewegungsdetektion mit digitaler Signalauswertung	Frey Fuchs/Feller

Max W. Schlegel	Adaptive Algorithmen zur Brand-erkennung	Dauwels
Thomas Guignard	L'orgue de verre	Heutschi Martin/EPFL

Diploma Theses SS 2003

Nicolas Cedraschi	Computing Information Rates of Channels with Phase Noise	Dauwels Koch Hösli
Wim Meerschman	Signal Processing in Wearable Computing Systems using Factor Graphs	Dauwels

3. Research

3.1 Research Areas

The Signal and Information Processing Lab focusses on research and teaching in the following areas:

Information Theory and Coding

Information theory, error correcting codes, and their application to communication systems. Current topics:

- Bounds on the capacity of fading channels
- The poisson channel at high intensities
- Bounds on the capacity of free-space optical intensity channels
- On multi-access channels (MAC) at high SNR
- On MIMO ricean fading channels
- The capacity region of the poisson multiple-access channel with noiseless feedback
- Optimizing antenna arrays using genetic algorithms
- Capacity of the Gaussian channel with causal side information at the transmitter (“dirty tape” channel)
- Numerical computation of information

Digital Signal Processing

Current topics:

- Fundamentals of graphical models (“factor graphs”)
- Speech enhancement in hearing aids
- Decomposition of electromyographic signals
- Clock noise and synchronization in communications receivers

Analog Signal Processing

Current topics:

- Decoding in analog VLSI
- Synchronization of pseudo random signals

3.2 Current Research Projects

Information Theory and Coding

On the feedback Capacity of Discrete-time Multi-Access Channels

An achievable region for the two-user discrete memoryless multiple-access channel with noiseless feedback is derived. The proposed region includes the Cover-Leung region, with the inclusion being for some channels strict.

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Professor: Dr. Amos Lapidoth

On the Computational Cut-off Rate for Rayleigh and Ricean Fading Channel without Receiver Side Information

We demonstrate how duality theory can be used to derive upper bounds on the channel cut-off rate. For the Ricean fading channel, we obtain the high signal-to-noise ratio (SNR) expansion of the cut-off rate.

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Professor: Dr. Amos Lapidoth

Duality-based Bounds on Error Exponents

We study a dual expression for the random coding error exponent where the maximization over input distributions is replaced with a minimization over output distributions. Using this technique we can derive UPPER bounds on the random coding error exponent and on the sphere packing exponents.

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Professor: Dr. Amos Lapidoth

On the capacity of Multi-Input Multi-Output Ricean Fading Channels with Perfect Side-Information

We prove that the capacity of a MIMO Ricean channel with perfect receiver side-information is monotonic in the singular values of the mean matrix. This result is derived for the optimal power allocation scheme and not only for the uniform one.

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Professor: Dr. Amos Lapidoth

Isotropic Gaussian Rates for Multi-Input Multi-Output Ricean Fading Channels with Perfect Side-Information

We prove that the mutual information corresponding to an isotropically distributed Gaussian input to a Ricean multi-antena channel with perfect receiver side information is monotonic in the singular values of the mean matrix.

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Capacity of the Gaussian Channel with Causal Side Information at the Transmitter ("Dirty Tape" Channel)

In many communication scenarios the channel is time-varying and can be modeled with a state-dependent channel law. If only the transmitter has some knowledge about the underlying state process the calculation of the channel capacity usually requires the consideration of an extended input alphabet and seems to be a hard problem in general. A particular case of such a scenario is the so-called dirty tape channel. Apart from the often employed additive noise component this model assumes that the current state is determined by another additive interference that is known causally at the sender. In this project we considered the problem of finding the capacity-cost function of this channel, i.e., the capacity given that the sender is allowed to use at most a given average cost. Different aspects like for instance discretisation of the alphabets and in particular the capacity per unit cost have been investigated.

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Optimizing Antenna Arrays Using Genetic Algorithms

Antenna arrays can be deployed at the receiver of a communication system to retain desiredsignals from particular directions while rejecting undesired components from other directions. Different array geometries lead to different array patterns (also called beamformers), which yield the antenna gain as a function of the incident angle. In this project different array geometries (1 and 2-dimensional) with isotropic element patterns have been investigated. The hardware complexity of full regular arrays can be reduced by thinning them out. At the same time some specifications regarding the array pattern have to be fulfilled. For example, a high ratio of the mainlobe level to the sidelobe level is desired. Since the number of possible array configurations increases exponentially with the number of antenna elements, an exhaustive search for the best configuration is not feasible. As an alternative genetic algorithms have been employed in order to find optimum solutions with respect to the specifications. In particular, classic GA's have been compared to so-called micro GA's with very small populations. MATLAB has been used for the simulations.

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In Collaboration with: Elektrobit AG, Bubikon (Switzerland)

The Capacity Region of the Poisson Multiple-Access Channel with Noiseless Feedback

The Poisson multiple-access channel (MAC) models a many-to-one optical communication system. Its capacity region has recently been computed by Lapidoth & Shamai. The purpose of the present research is to investigate the gains (in capacity) afforded by noiseless delayless feedback from the receiver to the transmitters

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On MIMO Ricean Fading Channels with Feedback

In this project we study the capacity of a multiple-transmit multiple-receive system operating over Ricean fading channels. The transmitter is assumed to employ spatially and temporally white Gaussian inputs, and the receiver is assumed to possess perfect knowledge of the realization of the fading process. We prove that the mutual information corresponding to such scenarios is componentwise monotonic in the vector of the singular-values of the mean matrix. The dependence on the variance of the fading is under current investigation.

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On Multi-Access Channels (MAC) at High SNR

Multi-access channels model many-to-one communication scenarios, as for example, the uplink in mobile cellular telephony. Contrary to the case of single-user communication via multiple transmit antennae, a multiple-access scenario allows for very limited cooperation among the transmitters, as each transmitter is assumed to be ignorant of the message transmitted by the other users. In this project we investigate a fading multiple-access channel in the absence of receiver side information. We model the received signal as the sum of two signals, where the first signal is the result of passing the signal transmitted by the first user through a Ricean fading channel, and the second signal defined analogously.

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The Poisson Channel at High Intensities

The study of the Poisson channel has a long history, as it is one of the key models for optical communication. Of special interest is channel capacity, which is the highest rate at which reliable communication is achievable over this channel. Since, the model is highly non-linear (with the output being a Poisson random

variable of a mean that is proportional to the input), no closed-form expression for the capacity is known. In this project we study the asymptotic behavior of channel capacity at high intensities. Our approach is based on a new paradigm - a paradigm based on the notion of capacity achieving input distributions that escape to infinity - that we have introduced for the study of channels at high signal-to-noise ratios.

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Bounds on the Capacity of Fading Channels

The goal of this project is to obtain ccurate estimates of the capacity of fading channels, which are typically encountered in mobile wireless communication. The capacity of such channels serves as the ultimate upper bound on the rates at which reliable communication is possible. Moreover, with the advent of Turbo-codes, one can often approach these rates with practical coding schemes. Since the exact calculation of capacity is intractable, one must resort to upper and lower bounds. To this end we have developed a new technique to derive upper bounds on the capacity of general channels, and we have applied this technique to fading channels. Together with some lower bounds that we have found for such channels, we are now in a position to understand the behavior of the channel capacity for the large family of multi-antenna fading channels with or without memory and with or without side information related to the fading realization. We have further developed the concept of quot; capacity achieving input distributions that escape to infinity& quot; and showed how his concept can be used to derive asymptotic estimates of channel capacity. Using this paradigm we were able to derive a high-SNR asymptotic expansion for the capacity of a number of fading models. In particular we have solved the single-input single-output (SISO) case (with memory) as well as the multi-input single-output (MISO) case.

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Numerical Computation of Information Rates

The information rate and the channel capacity (in the sense of Shannon) are key properties of any communications channel. However, for many important channels with memory, it is not known how to compute these quantities with sufficient accuracy.

Since 2001, we have made significant progress with such numerical methods. In particular, the information rate of any finite-state source/channel model (with up to a few thousand states) can now be computed accurately. Upper and lower bounds on the information rate of very general (non finite-state) channels can be computed either by finite-state approximations or by reduced-state trellis computations. We are now extending this work to make use of "particle filter" methods.

In collaboration with A. Kavcic, we have also been studying an extension of the Blahut-Arimoto algorithm to optimize the information rate over finite-state Markov sources with a fixed number of states.

This work was motivated mainly by applications in magnetic recording, but the results have a much wider scope.

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Digital Signal Processing

Basics of Graphical Models

Most of our research is somehow related to graphical models (factor graphs) and to message passing algorithms on such graphs. We are interested in a wide variety of conceptual and algorithmical issues. Examples include system identification, adaptation and learning, structured-summary propagation, electrical networks and other physical systems as factor graphs, Fourier duality and Lagrange duality, particle methods, and applied signal processing by summary propagation.

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Clock Noise and Synchronization

This project is concerned with the following two related topics:

- Phase synchronization in communication receivers.

- Effects of nonideal clocks in communication receivers.

These topics are of central, and growing, importance to digital communications, but not well understood. We are studing these topics from several sides: physics and circuit theory, information theory, and signal processing. We heavily rely on modeling by factor graphs and signal processing by the summary-product algorithm.

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Decomposition of EMG Signals

All muscular activity is triggered by electrical pulses in the nerve cells that control individual groups ("motor units") of muscle fibres. The measurement and the analysis of such electrical signals is of significant interest to physicians.

Our laboratory has a long tradition in the processing of such electromyographic (EMG) signals. The signals as measured by various types of electrodes consist of the linear superposition of (the signals corresponding to) many motor units. The main signal processing task is to identify the "signatures" of the individual motor units and to decompose the measured signal into the corresponding components.

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Speech Enhancement in Hearing Aids

In noisy environments, the perceived quality of speech signals in hearing aids is often unsatisfactory. We are studying the enhancement of such speech signals in two separate approaches.

1. Use of two microphones. Here we focus on the "blind" identification of linear filters for noise reduction. A first goal is to understand the achievable speech quality by "optimal" linear filtering under a variety of conditions.

2. Model-based nonlinear filtering. We use factor graphs to specify a variety of generalized hidden Markov models and we explore many versions of the summary-product algorithm to clean up the signals.

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Supported by: KTI, Phonak AG Stäfa

Analog Signal Processing

Decoding and More in Analog VLSI

Error correcting codes may be represented by "factor graphs", and iterative "probability propagation" decoding operates by "message passing" along the edges of the graph. Back in 1998, we discovered that the factor graph of many error correcting codes (including trellis codes, turbo codes, and low-density parity check codes) can be translated directly into analog transistor circuits that operate in continuous time and in parallel. Such analog decoders are composed of "probability gates", where currents represent probabilities and voltages represent logarithms of probabilities (or of probability ratios). Such analog decoders might allow the use of error correcting codes in applications where digital decoders would be too slow or would consume too much power.

We have built simple decoder chips as well as a collection of "probability gates" as individual integrated circuits; the latter allowes us to put together and to study several simple decoders on the breadboard level.

More recently, we have extended analog probability-propagation to synchronization. We have demonstrated that a clockless continuous-time circuit can synchronize to a properly designed periodic waveform, even in the presence of substantial noise. This work also sheds some light on the connection between statistical state estimation and the subject of "entrainment" of dynamical systems.

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3.3 Completed Research Projects

GAO Qun

Fingerprint Verification using Cellular Neural Networks

ETH Diss. Nr. 15152 (Referee: Prof. Dr. H.-A. Loeliger)

In this thesis, a CNN-based fingerprint verification system is realized. It consists of three main processing stages, Image Preprocessing, Feature Extraction and Feature Matching, and a system database.

In the Image-Preprocessing stage, the quality of an original gray-scale noisy fingerprint image is enhanced. As a result, a binary thinned fingerprint is obtained. In the Fingerprint Feature-Extraction stage, distinguishable real features (ridge endings and ridge bifurcations) in the thinned fingerprint as well as their feature attributes are extracted. False features are eliminated based on a distance criterion. In the subsequent Fingerprint Feature-Matching stage, a similarity comparison scheme which is tailor-made for CNNs is presented. It is able to tackle the translation distortion inherent in fingerprint images. A special system database is proposed which takes the rotation distortion into account by storing not only the feature images of the system user's fingerprint, but also their rotated versions. This greatly facilitates the similarity comparison scheme, thus speeding up the feature matching process. For the final decision, several criteria are investigated and a combination of two simple criteria with an adjustable parameter is proposed.

The performance of the whole system, i.e., the ability of the system to verify fingerprints which belong to the system user and the ability to reject fingerprints which belong to imposters who are not justified to access the system, is evaluated by using a real fingerprint test database. Due to the great variation in quality between different fingerprints even from the same user, the concept of "optimum fingerprint version" is proposed for the enrollment mode in order to improve the False Rejection Rate of the system when only one fingerprint is allowed to be stored. If memory allows to store more than one fingerprint, the concept of "best combination" of available fingerprints is presented. Moreover, we show that through adjusting the parameter in he decision criteria, the system can be used for applications requiring high security as well as for forensic applications. In practice, the system has to trade off between the False Rejection Rate and the False Acceptance Rate in order to satisfy the requirements of a specific application.

Two issues related to hardware implementation, robustness and processing speed of the system, are addressed as well. By introducing template decomposition, the robustness of high-connectivity bipolar CNNs is enhanced, thus increasing the robustness of the corresponding stage. The price to be paid is an increase in settling time. The interdependence between robustness and settling time due to template decomposition is studied. For gray-scale CNNs (for which the definition of

robustness used here is meaningless, since it would be equal to zero), a new measure, perturbation tolerance, is introduced to quantify the ability of a gray-scale CNN to tolerate template parameter inaccuracies. By definition, the robustness of a CNN is a special case of its perturbation tolerance. In addition, for the Binarization operation, the maximum perturbation of template parameters allowed is derived.

Finally, with the aim of exploiting the potential of CNNs in the area of general image processing and pattern recognition, a CNN-based rotation algorithm is designed to rotate binary images. Image rotation is realized by shifting black pixels successively along their individual paths which are predetermined in a control image. The control image specifies the shifting direction and the shifting speed of each pixel.

3.4 Completed Dissertations

GAO Qun — Fingerpring Verification using Cellular Neural Networks

ETH Diss. Nr. *15152*
Referee: Prof. Dr. H.-A. Loeliger
Co-referee: Prof.em. Dr. G.S. Moschytz
Prof. T. Roska, Budapest

4. Congresses, Meetings and Committees

4.1 Congress Organization

Prof. Lapidoth

Co-Chair of the 2003 Winter School on Coding and Information Theory.

Member of the Programm Committee for the 2004 International Zurich Seminar.

Organizer of the 2004 4th ETH-Technion Workshop on Information and Communication Theory.

Prof. Loeliger

Chairman, 2004 International Zurich Seminar on Communications.

Co-Chair of the 2003 Winter School on Coding and Information Theory.

Chairman, 2nd Analog Decoding Workshop.

Member of the Technical Program Committee, 3rd Int. Symposium on Turbo codes and Related Topics.

4.2 Participation in Congresses and Meetings

Dauwels Justin	Probability and Statistical Mechanics in Information Science, Centro di Ricerca Matematica Ennio De Giorgi, Pisa, Italy, 16. – 20.6.2003.
Dauwels Justin	Avogadro-Scale Engineering: Form and Function, Center for Bits and Atom, MIT Cambridge, USA, 18. – 19.11.2003.
Dauwels Justin	Research Stay with MIT Medialab, Physics and Media Group, Cambridge, USA, 3.10. – 15.12.2003.
Frey Matthias Merkli Patrick	ISCAS 2003, Bangkok, Thailand, 26. – 28.5.2003.
Frey Matthias Loeliger Hans-Andrea Merkli Patrick	2nd Analog Decoding Workshop, Zurich, Switzerland, 8.9.2003.
Hofbauer Markus	ICA 2003, Fourth International Symposium on independent Component Analysis and Blind Signal Separation, Nara, Japan, 1. – 4.4.2003.
Hofbauer Markus	IWAENC 2003, Eight International Workshop on Acoustic Echo and Noise Control, Kyoto, Japan, 8. – 11.9.2003.
Dauwels Justin Hösli Daniel Lapidoth Amos Loeliger Hans-Andrea Miliou Natalia Moser Stefan Ostojic Maja	2003 Winterschool on Coding and Information Theory Monte Verità, Ascona, Switzerland, 24. – 27.2.2003.
Korl Sascha	2003 IEEE Workshop, Neural Networks for Signal Processing, Toulouse, France, 16. – 19.9.2003.
Lapidoth Amos Loeliger Hans-Andrea	2003 IEEE Information Theory Workshop, La Sorbonne, Paris, France, 30.3. – 4.4.2003.
Dauwels Justin Lapidoth Amos Loeliger Hans-Andrea	2003 IEEE Int. Symposium on Information Theory, Yokohama, Japan, 29.6. – 4.7. 2003.
Lapidoth Amos Miliou Natalia Moser Stefan	Summer Research Institute, EPFL, Lausanne, Switzerland, 21. – 25.7.2003.

Lapidoth Amos Loeliger Hans-Andrea Moser Stefan	41st Annual Allerton Conference on Communic., Control and Computing, Allerton, USA, 1. – 3.10.2003.
Lapidoth Amos Loeliger Hans-Andrea	2nd Joint Workshop on Communications and Coding, Nuits-Saint-Georges, France, 19. – 22.10.2003.
Lapidoth Amos	FTW Vienna, Austria, 11. - 14.12.2003.
Loeliger Hans-Andrea	E*PCOS 2003 (European Symposium on Phase Change Optical Storage), Hotel Serpiano, Lake Lugano, Switzerland, 10. – 11.3.2003.
Loeliger Hans-Andrea	Nonlinear Dynamics of Electronic Systems (NDES) 2003, Scuol, Switzerland, 18. – 21.5.2003.
Loeliger Hans-Andrea	3rd International Symposium on Turbo Codes & Related Topics, Brest, France, 1. – 5.9.2003.
Loeliger Hans-Andrea	Coding Theory Seminar, Math. Forschungs-institut Oberwolfach, Germany, 8. – 12.12.2003.

4.3 Service Activities and Society Memberships

Prof. Lapidoth

Fellow of the IEEE

Member of the IMS Institute of Mathematical Statistics, Bethesda, USA

Associate Editor for Shannon Theory, IEEE New York

Prof. Loeliger

Fellow of the IEEE

Chairman of the IEEE Switzerland Chapter on Digital Communication Systems

Associate Guest Editor, IEEE Transactions on Signal Processing

Member of Proposal Preparation Committee of NEWCOM

Dr. Heutschi

Member, Acoustical Society of America

Member, Audio Engineering Society

Member, Swiss Acoustical Society (SGA)

Member, German Acoustical Socyety (DEGA)

4.4 Presentations by Institute Members

Dauwels Justin	"Carrier Synchronization using Factor Graphs", 2003 Winterschool on Coding and Information Theory, Monte Verità, Ascona, Switzerland, 24. – 27.2.2003.
Dauwels Justin	"Joint Decoding and Phase Estimation: an Exercise in Factor Graphs", ISIT 2003, Pacifico Yokohama, Japan, 29.6. – 4.7.2003.
Dauwels Justin	"Turbo Signal Processing", Digital Communications Research Group, Ghent University, Ghent, Belgium, 11.11.2003.
Dauwels Justin	"Loeliger's Universe", MIT Media Lab., Physics and Media Group, Cambridge, USA, 4.12.2003.
Frey Matthias	"Measurements and Observations on Analog Decoders for an [8, 4, 4]-extended Hamming Code", 2nd Analog Decoding Workshop, Zurich, Switzerland, 8.9.2003.
Frey Matthias	"A Brief Introduction to Analog Decoding", JETRO (Japan external trade organization), Zurich, Switzerland, 3.9.2003.
Hofbauer Markus	"Limitations of FIR Multi-microphone Speech Dereverberation in the low-Delay Case", IWAENC 2003 Eight International Workshop on Acoustic Echo and Noise Control, Kyoto, Japan, 8. – 11.9.2003.
Hösli Daniel	"On the Capacity of the Dirty Tape Channel per Unit Cost", Winterschool on Coding and Information Theory, Monte Verità, Switzerland, 25.2.2003.
Lapidoth Amos	"On Expected Log Determinant of Non-Central Wishart Matrices", ISIT 2003, Yokohama, Japan, 30.6.2003.
Lapidoth Amos	"Fading Channels at High SNR: Facts and Artifacts", 41st Annual Allerton Conference on Communication, Conrol, and Computing, 1. - 3.10.2003.
Lapidoth Amos	"On the High SNR Capacity of Stationary Gaussian Fading Channels", 2nd Joint Workshop on Communications and Coding, Nuits-St.-Georges, France, 19. - 22.10.2003.

Lapidoth Amos	"The Asymptotics of Fading Channels: Facts and Artifacts", FTW Vienna, Austria, 11. – 14.12.2003.
Loeliger Hans-Andrea	"On Coding and Signal Processing for Storage Media", E*PCOS 2003 (European Symposium on Phase Change Optical Storage), Hotel Serpiano, Lake Lugano, Switzerland, 10. – 11.3.2003.
Loeliger Hans-Andrea	"Circuits and Probabilities", Nonlinear Dynamics of Electronic Systems (NDES) 2003, Scuol, Switzerland, 18. – 21.5.2003.
Loeliger Hans-Andrea	"On Structured-Summary Propagation, LFSR Synchronization, and Low-Complexity Trellis Decoding", 41st Allerton Conference on Communication, Control, and Computing, Monticello, IL., USA, 1. – 3.10.2003.
Loeliger Hans-Andrea	"Some Remarks on Factor Graphs", 3rd International Symposium on Turbo Codes & Related Topics, Brest, France, 1. – 5.9.2003.
Loeliger Hans-Andrea	"On Structured-Summary Propagation, LFSR Synchronization, and Low-Complexity Trellis Decoding", 2nd Joint Workshop on Communications and Coding, Nuits-Saint-Georges, France, 19. – 22.10.2003.
Loeliger Hans-Andrea	"On Structured-Summary Propagation and LFSR Synchronization", Coding Theory Seminar, Math. Forschungsinstitut Oberwolfach, Germany, 8. – 12.12.2003.
Loeliger Hans-Andrea	"Signal Processing with Factor Graphs", 2003 Winterschool on Coding and Information Theory, Monte Verità, Ascona, Switzerland, 24. – 27.2.2003.
Loeliger Hans-Andrea	"Simulation-based Computation of Information Rates: Upper and Lower Bounds", 2003 IEEE International Symposium Information Theory (ISIT), Yokohama, Japan, 29.6. – 4.7.2003.
Loeliger Hans-Andrea	"On Circuits and Probabilities", 2nd Analog Decoding Workshop, ETH Zurich, Switzerland, 8.9.2003.
Merkli Patrick	"Measurements & Observations on Analog Decoders for an [8, 4, 4]-extended Hamming Code", 2nd Analog Decoding Workshop, ETH Zurich, Switzerland, 8.9.2003.

Miliou Natalia	"Duality Based Bounds on the Cut-off Rate of a Discrete-Time Memoryless Ralyleigh Fading Channel", 2003 Winterschool on Coding and Information Theory, Monte Verità, Ascona, Switzerland, 26.2.2003.
Moser Stefan	"The Asymptotic Capacity of the Discrete-Time Poisson Channel", 2003 Winterschool for Coding and Information Theory, Monte Verità, Ascona, Switzerland, 24.2.2003.
Moser Stefan	"On the Ricean Fading Multi-Access Channel", 2003 Winterschool for Coding and Information Theory, Monte Verità, Ascona, Switzerland, 26.2.2003.

4.5 Organization of Lectures, Seminars, and Colloquia

Colloquium Speakers for the Colloquium "Electronics and Communications" were:

Invited by Prof. Lapidoth:

06.01.03 **Prof. Ezio Biglieri,** Politecnico di Torino, Torino, Italy
"Coding for Multiple Antennas with Linear and Nonlinear Suboptimum Interfaces".

13.01.03 **Prof. Dr. M. Vetterli,** EPF Lausanne, Switzerland
"Sampling Signals with Finite Rate of Innovation; is there Life below Nyquist?".

20.01.03 **Prof. Dr. Ueli Maurer,** ETH Zurich, Switzerland
"Index Search, Discrete Logarithms, and Diffie-Hellmann".

27.01.03 **Prof. David Forney,** MIT Boston, USA
"Topics in Comm., Information Theory and Signal Processing".

31.01.03 **Thomas Marzetta,** Bell Labs, Murray Hill, NJ, USA
"Fundamental Limitations of MIMO Wireless Links that use Polarimetric Antenna Arrays".

03.02.03 **Dr. Jossy Sayir,** FTW Vienna, Austria
"Is there a "good" and a "bad" Redundancy?"

18.12.03 **S. Vishwanath,** Stanford University, Stanford, CA, USA
"Duality, Achievable Rates, Outer Bounds and Sum Capacity of Gaussian Vector Broadcast Channels".

Invited by Prof. Loeliger:

10.04.03 **Prof. Christian Schlegel,** University of Alberta, Edmonton, AB Canada
"Performance and Complexity of CDMA Iterative Multiuser Detection".

19.06.03 **Prof. Allen G. Lindgren,** University of Rhode Island, Kingston, USA
"Cochlear Mechanics from a Signal Processing Viewpoint".

23.12.03 **Dr. Pascal Vontobel,** University of Illinois at Urbana, Urbana, IL, USA
"Graph Covers and Iterative Decoding of Finite-Length Codes".

Invited by Dr. Heutschi

15.01.03 **Prof. Dr. Ottar Johnsen,** Ecole d'ingénieurs et d'architectes de Fribourg, Switzerland
"Visualaudio: A Technique to Extract the Sound from Old Records".

22.01.03 **Dr. Alfred Stirnemann,** Computer Modeling & Simulation, Phonak AG, Stäfa, Switzerland
"Modellierung rund ums Hörgerät".

09.04.03 **Prof. Dr.-Ing. Markus Hecht,** Institut für Land- und Seeverkehr, Technische Universität, Berlin, Germany
"Lärmbelastung durch Schienengüterverkehr, Ist-Situation und Minderungsmöglichkeiten mit Focus leise Fahrzeuge".

07.05.03 **Prof. Dr.-Ing. habil, Wolfgang Ahnert,** ADA Acoustic Design Ahnert, Berlin, Germany
"Die Simulation von Grossbeschallungen – erläutert am Beispiel von Stadionbeschallungen unter Beachtung der Anforderungen und Vorschriften".

5. Publications

Arnold Dieter Kavcic Aleksandar Loeliger Hans-Andrea Vontobel Pascal O. Zeng Wei	"Simulation-Based Computation of Information Rates: Upper and Lower Bounds", Proc. 2003 IEEE Int. Symposium on Information Theory, p. 119, Yokohama, Japan, June 29 - July 4, 2003.
Dauwel Justin Loeliger Hans-Andrea	"Joint Decoding and Phase Estimation: an Exercise in Factor Graphs", Proc. 2003 IEEE Int. Symposium on Information Theory, p. 231, Yokohama, Japan, June 29 - July 4, 2003.
Dauwels Justin Loeliger Hans-Andrea Merkli Patrick Ostojic Maja	"On Structured-Summary Propagation, LFSR Synchronization, and Low-Complexity Trellis Decoding", Proc. 41st Allerton Conf. on Communication, Control, and Computing, Monticello, Illinois, Oct. 1-3, 2003.
Dougherty R. F. Koch V. M. Brewer A. A. Fischer B. Modersitzki J. Wandell B. A.	"Visual Field Representations and Locations of Visual Areas V1/2/3 in Human Visual Cortex", Journal of Vision, vol. 3, no. 10, pp. 586-598, January, 2003.
Frey Matthias Loeliger Hans-Andrea Lustenberger Felix Merkli Patrick Strebel Patrik	"Analog-Decoder Experiments with Subthreshold CMOS Soft-Gates", Proceedings of the 2003 IEEE International Symposium on Circuits and Systems, pp. 85-88, Bangkok, Thailand, May, 2003.
Hofbauer Markus	“Limitations of FIR Multi-microphone Speech Dereverberation in the low-Delay Case“IWAENC 2003 Eight International Workshop on Acoustic Echo and Noise Control, Kyoto, Japan, September, 2003.
Hoesli Daniel	"On the Capacity per Unit Cost of the Dirty Tape Channel", Proceedings 2003 Winter School on Coding and Information Theory, Monte Verita, Switzerland, February 24-27, 2003.
Hoesli Daniel Lapidoth Amos	"The Capacity of a MIMO Ricean Channel is Monotonic in the Singular Values of the Mean", to appear in the Proceedings of the 5th International ITG Conference on Source and Channel Coding (SCC), Erlangen, Nuremberg, Germany, January 14-16, 2003.

Lapidoth Amos	"On the High SNR Capacity of Stationary Gaussian Fading Channels", Proceedings 41st Annual Allerton Conference on Communication, Control, and Computing, Monticello, IL, USA, October 1-3, 2003.
Lapidoth Amos Miliou Natalia	"Duality Based Bounds on the Cut-Off Rate of a Discrete-Time Memoryless Rayleigh Fading Channel", Proceedings Winter School on Coding and Information Theory, Ascona, Switzerland, February 24-27, 2003.
Lapidoth Amos Bross Shraga	“An improved achievable region for the discrete memoryless two-user MAC with noiseless feedback“, Proceedings ISIT 2003, Yokohama, Japan, p. 310, June 29–July 4, 2003.
Lapidoth Amos Kim Young-Han	“On the Log Determinant of Non-Central Wishart Matrices“, Proceedings ISIT 2003, Yokohama, Japan, p. 310, June 29-July 4, 2003..
Lapidoth Amos Moser Stefan M.	"Bounds on the Capacity of the Discrete-Time Poisson Channel", Proceedings 41st Annual Allerton Conference on Communication, Control, and Computing, Monticello, IL, USA, October 1-3, 2003.
Lapidoth Amos Moser Stefan M.	"The Asymptotic Capacity of the Discrete-Time Poisson Channel", Proceedings 2003 Winter School on Coding and Information Theory, Monte Verita, Ascona, Switzerland, February 24-27, 2003.
Lapidoth Amos Moser Stefan M.	"On the Ricean Fading Multi-Access Channel", Proceedings 2003 Winter School on Coding and Information Theory, Monte Verita, Ascona, Switzerland, February 24-27, 2003.
Lapidoth Amos Moser Stefan M.	"Capacity Bounds via Duality with Applications to Multiple-Antenna Systems on Flat Fading Channels", IEEE Transactions on Information Theory, vol. 49, no. 10, pp. 2426-2467, October, 2003.
Loeliger Hans-Andrea	"Some Remarks on Factor Graphs", Proc. 3rd Int. Symp. on Turbo Codes and Related Topics, pp. 111-115, Brest, France, Sept. 1-5, 2003.
Vontobel Pascal O. Loeliger Hans-Andrea	"On factor graphs and electrical networks", Mathematical Systems Theory in Biology, Communication, Computation, and Finance, J. Rosenthal and D.S. Gilliam, eds, IMA Volumes in Math. and Appl., pp. 469-492, Springer Verlag, 2003.
Vontobel Pascal O. Loeliger Hans-Andrea	"Factor Graphs and Dynamical Electrical Networks", Proc. 2003 Information Theory Workshop, pp. 218-221, Paris, France, March 31-April 4, 2003.
Zennaro Daniel	"A Software Package for the Decomposition of Long-

Wellig Peter
Koch Volker M.
Moschytz George S.
Läubli Thomas

Term Multichannel EMG Signals Using Wavelet Coefficients", IEEE Transactions on Biomedical Engineering, vol. 50, no. 1, pp. 58-69, January, 2003.

6. Guests, Visitors

6.1 Activities of Academic Guests at the Institute

Guests of Prof. Loeliger:

Prof. Allen G. Lindgren,
University of Rhode Island, Kingston, USA
Collaboration on signal processing for hearing aids. 01.06.-31.07.03

Benjamin Vigoda
MIT Media Lab, Cambridge USA
Collaboration on the synchronization of pseudo-noise signals
both in discrete time and in continuous time. 23.04.-28.04.03

7. Honors and Awards

Lapidoth Amos	Fellow of the IEEE (Institute of Electrical and Electronics Engineers, Inc.), December 03.
Loeliger Hans-Andrea	Fellow of the IEEE (Institute of Electrical and Electronics Engineers, Inc.), December 03.