# Signal and Information Processing Laboratory

Prof. Dr. A. Lapidoth, Prof. Dr. H.-A. Loeliger, Prof. Em. Dr. F. Eggimann,
Dr. K. Heutschi

# ANNUAL REPORT

# 2 0 0 1

**Research Period 2001**

**Teaching Period 2000/2001**

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|---|---|
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# Foreword

The year 2001 brought again many changes to our lab, mostly of a happier nature than the events which dominated that year's news. Among the less happy events is the retirement of Prof. Fritz Eggimann, who, in addition to his main job as the director of the Eidg. Materialprüfungs- und Forschungsanstalt (EMPA), had been affiliated with this lab since 1988. Our best wishes and our gratitude accompany him.

The latest group of fresh PhDs — Peter Wellig, Marcel Joho, and Heinz Mathis — also left us in 2001. On the other hand, a bunch of new PhD students has arrived: Sascha Korl, Matthias Frey, Volker Koch, and Daniel Hösli.

In addition, Mr. Patrik Strebel (Dipl. Ing. HTL) joined our permanent staff and has already made significant contributions to our research project on analog decoders.

As for myself, I had the good furtune to join this lab 20 months ago, and I greatly enjoy to be here. To have Amos Lapidoth as a collegue is a privilege, and the support by our permanent staff — Mrs. Agotai, Mr. Amatore, Mr. Dünki, Mrs. Röösli, and Mr. Schärer — is outstanding. In such circumstances, it is easy to look confidently into the future.

February 2002 Prof. H.-A. Loeliger

# Contents

# 1. Personnel

Professor for Information Theory:

**Prof. Dr. Amos Lapidoth**

Professor for Signal Processing:

**Prof. Dr. Hans-Andrea Loeliger**

Professor for Information Technology:

**Prof. Dr. Fritz Eggimann**
**retired since 31.3.2001**

| | | | |
|---|---|---|---|
| Adjunct Lecturer: | **Dr. K. Heutschi** | | |
| Secretaries: | **Mrs. Bernadette Röösli** | | |
| | **Mrs. Renate Agotai** | | |
| | **Mrs. Heidi Schenkel** | | |
| Administr.Supervisor: | **Dr. Marcel Joho** | left on 28.2.01 | |
| Technical Supervisor: | **Dr. Max Dünki** | | |
| Research Assistants: | **Dieter Arnold** | Dipl.El.Eng. | |
| | **Justin Dauwels** | Dipl.Phys.Eng. | |
| | **Frey Matthias** | Dipl.El.Eng. | since 1.8.01 |
| | **Qun Gao** | Dipl.El.Eng. | |
| | **Markus Hofbauer** | Dipl.El.Eng. | |
| | **Hösli Daniel** | Dipl.El.Eng. | since 18.10.01 |
| | **Koch Volker** | Dipl.-Ing. | since 19.10.01 |
| | **Korl Sascha** | Dipl.-Ing. | since 1.3.01 |
| | **Ralf Kretzschmar** | Dipl.Phys. | |
| | **Dani Lippuner** | Dipl.El.Eng. | |
| | **Felix Lustenberger** | Dipl.El.Eng. | |
| | **Heinz Mathis** | Dipl.El.Eng. | |
| | **Patrick Merkli** | Dipl.Ing. Microtechn.EPF | |
| | **Stefan Moser** | Dipl.El.Eng. | |
| | **Pascal Vontobel** | Dipl.El.Eng. | |
| | **Wellig Peter** | Dipl.El.Eng. | left 31.1.01 |
| Technical Staff: | **Francesco Amatore** | | |
| | **Thomas Schaerer** | | |
| | **Strebel Patrik** | El.Ing.HTL | since 1.4.01 |

**Academic Guests:** (see 6.1 for report of activities)

| | | |
|---|---|---|
| **Prof. Sanjoy Mitter** | MIT, Cambridge, USA | 02.04. - 31.05.01 |
| **Prof. Sergio Verdú** | Princeton University, Princeton, USA | 06.07. - 09.07.01 |
| **Prof. Scott Douglas** | Southern Methodist University Dallas, USA | 14.07. - 17.07.01 |
| **Prof. Allen Lindgren** | University of Rhode Island, Kingston, USA | 01.08. - 15.09.01 |
| **Benjamin Vigoda** | MIT, Cambridge, USA | 27.08. – 30.08.01 |
| **Prof. Shlomo Shamai** | Technion – Israel Institute of Technology, Haifa, Israel | 10.11. – 12.11.01 |

# 2. Teaching

## 2.1 Lectures and Practica

| Sem. | Instructors | Title | ETH-No. |
|---|---|---|---|
| 5th | Prof. H.-A. Loeliger | Zeitdiskrete Systeme & stochastische Signale | 35-405 |
| 6th | Prof. H.-A. Loeliger | Digitale Signalverarbeitung und Filterung | 35-416 |
| 5/7th | Prof. A. Lapidoth | Applied Digital Information Theory I | 35-417 |
| 8th | Prof. A. Lapidoth | Applied Digital Information Theory II | 35-418 |
| 7th | Prof. F. Eggimann<br>M. Hofbauer | Adaptive Filter & neuronale Netzwerke | 35-467 |
| 8th | H.P. Schmid | Analoge Signalverarbeitung und Filterung | 35-468 |
| 7th | Dr. K. Heutschi | Acoustics I | 35-477 |
| 8th | Dr. Heutschi | Acoustics II | 35-478 |
| 5/ 6th | Practica | Laboratory for "Fundamentals in Electrical Engineering" | 35-095/6 |
| 2nd | Prof. H.-A. Loeliger | Cellular Automata | PPS |
| 3rd/4th | Prof. H.-A. Loeliger | Technical Presentations | PPS |

## 2.2 Semester Projects and Diploma Theses

During the winter semester 2000/01 and summer semester 2001, 4 Semester Projects (5 candidates) and 8 Diploma Theses (8 candidates) were carried out.

| Candidates | Title | Supervisor |
|---|---|---|
| **Semester Projects WS 2000/01 (7th Semester)** | | |
| Peter Oertig | Blinde Phasensynchronisation | Mathis, Joho |
| Philipp Zehnder | Blind and Semi-blind Equalization of Wireless Channels | Mathis, Joho |
| Giuseppe Acunto<br>Miquel Sans | Klassierung von Verkehrslärm | Hofbauer,<br>Oberle/Siemens |
| **Semester Projects SS 2001 (8th Semester)** | | |
| Michael Koller | Klassierung von Verkehrslärm | Oberle/Siemens<br>Lippuner,<br>Kälin/Siemens |
| **Diploma Theses WS 2000/01** | | |
| Gero Heidelberger | Iterative Methods for Blind Equalization | Mathis, Joho |
| Thomas Zwicker | Anwendung von Neuro-Fuzzy Systemen: Detektion überlappender Klassen | Kretzschmar,<br>Gao |
| Moritz Ritter | Anwendung von Neuro-Fuzzy Systemen: Boosting für die Wettervorhersage | Kretzschmar,<br>Moser,<br>Dauwels |
| Philippe Messmer | Rotation and Translation using Cellular Neural Networks for Fingerprint Recognition | Gao,<br>Kretzschmar |
| Philipp Foerster | Digital Signal Processing for Acoustics | Etter, Hofbauer |
| Matthias Frey | 1.05 GHz VCO for a BS-Receiver in 0.35µm CMOS | Prof. Takagi,<br>Lustenberger |
| Joel Niederhauser | Prediction of Epileptic Seizures based on Dept-EEG | Prof. Loeliger |
| **Diploma Theses SS 2001** | | |
| Thierry Königsberger | Pattern Classification: Detection of Dataless Regions performed by RBFs based on Linear Generator Functions | Kretzschmar |

# 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:

- Fundamental limits on reliable communication over fading channels
- Provably secure digital watermarking
- Coding for channels with transmitter side information
- Multi-user information theory
- Magnetic recording
- Capacity of finite state channels
- Algebraic code constructions for iterative decoding

**Digital Signal Processing**

Current topics:

- Adaptive filters for equalization and related applications in communications and acoustics
- Processing of electromyograms
- Weather prediction with neural networks

**Analog Signal Processing**

Signal processing with robust nonlinear analog networks. Current topics:

- Decoding of error correcting codes by analog circuits
- Fingerprint recognition using cellular neural networks

# 3.2 Current Research Projects

## Information Theory and Coding

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

The Poisson mutiple-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 noisless delayless feedback from the receiver to the transmitters.

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Keywords: Poisson Channel, Multiple-Access, Capacity region, Feedback.

In Collaboration with: Shraga Bross

### Bounds on the Capacity of Fading Channels

Fading channels, such as Rayleigh and Ricean channels, with or without memory are frequently used to model mobile wireless communication links. With the discovery of Turbo-codes, which are often capable of approaching channel capacity, the problem of computing the capacity of such channels has become of great importance. Since the exact calculation of capacity is intractable, one must resort to upper and lower bounds.

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 fading channels with or without memory.

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Professor: Prof. Dr. Amos Lapidoth

Keywords: Channel capacity, high SNR, fading, flat-fading, Ricean Fading, Rayleigh fading, convex programming, duality.

### Bounds on the Capacity of Poisson Channel

Channel capacity is an extremely important quantity, which is, alas, typically very difficult to compute precisely (even numerically). To address this problem, we have recently developed a new technique which can provide very tight upper bounds on channel capacity. This technique has been employed very successfully to the study of the capacity of fading channels, which are important to model wireless communication links.

In this project we investigate fiber optic transmission channels, which can be modelled as so called "Poisson channels". Applying our new bounding technique

we hope to reach the goal of finding some new bounds on the capacity of Poisson channels and to get a more profound understanding of the behaviour of this class of channels.

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Keywords: Channel capacity, fiber optic transmission channels, Poisson distribution, convex programming, duality.

**The Fading Number**

It has recently been shown that at high signal-to-noise ratios (SNR) the capacity of multi-antenna systems over flat fading channels (without receiver or transmitter side-information) typically grows only double-logarithmically in the SNR. Here we further refine the analysis and study the fading number, which is defined as the limitting difference between channel capacity log log SNR. While the use of multiple antennae does not typically change the double-logarithmic asymptotic dependence of channel capacity on the SNR, multiple antennae do typically increase the fading number, albeit at times (e.g., in the Rayleigh fading case) only in an additive way that grows only logarithmically with the number of antennae.

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Keywords: Fading Channels, Capacity, high SNR, fading number

**The Vector Gaussian Watermarking Game**

In this project we compute the coding capacity of the watermarking game for a vector Gaussian covertext and squared-error distortions. Both the private version where the covertex is available at the receiver and the public vesion where it is not, are addressed. It turns out that as in the scalar case, the two capacities are identical. Unlike the scalar case, the rate distortion solution (i.e., optimal compression) is sub-optimal.

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Keywords: Digital Watermarking, capacity, Gaussian, memory, rate distortion.

In Collaboration with: Aaron Cohen

**On the capacity region of broadband broadcast channels.**

Several models of wide-band broadcast communication scenarios are studied with an emphasis on conditions under which, as the bandwidth tends to infinity, time-sharing is asymptotically optimal. The models include the Gaussian channel, the

Poisson channel, the "very noisy" channel, and the average-power limited fading channel. Only stochastically degraded scenarios are studied.

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Keywords: Broadcast channels, wide band, time-sharing, Gaussian, Poisson, very noisy channel

In Collaboration with: I.E. Telatar and R. Urbanke

**Algebraic Coding and Iterative Decoding**

Channel coding deals with the problem of reliable communication over a noisy channel. In this project we aim at designing new channel codes based on algebraic principles and their representation by graphs. Rather than relying on algebraic decoding methods, we decode iteratively using the sum-product algorithm.

A main tool for this research are factor graphs, which are very well suited for representing codes and channels. Additionally, decoding by the sum-product algorithm can be interpreted as message passing along the edges of the graph.

The goal is to build a bridge between algebraic and turbo codes: finding factor graph representations of known codes and designing new codes with focus on block lengths no more than several thousand symbols. The construction of these codes should be based on ideas from algebra. We want to explore graph properties like cycles and connectivity; their impact on code parameters and especially on decoding performance are not well understood until now.

In the report period we have constructed codes derived from finite incidence structures (finite geometries) and codes derived from expander graphs with large girth. The resulting codes belong to the category of low-density parity-check (LDPC) codes, i.e. they have parity-check matrices which are sparsely filled with ones. The regular and irregular LDPC codes derived from Cayley graphs with large girth have a simple description, are easily encodable, have a large girth and a small diameter. We also presented a method which shows how one can get good interleavers for turbo codes from graphs with large girth.

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Keywords: algebraic coding, iterative decoding, factor graphs, low-density parity-check codes, turbo codes

Supported by: ETH

**Upper Bounds on the Capacity of Finite-State Machine Channels**

In the class of (time-invariant) finite-state machine channels are e.g. intersymbol-interference channels where the input is binary (+1/-1), the input signal is filtered by an FIR filter and white noise is added. Generalizing a result from channels without memory, we derived a method to compute upper bounds on the capacity of finite-state machine channels.

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Keywords: capacity, upper bound, finite-state machine channel, intersymbol-interference

### Magnetic Recording

The magnetic recording channel possesses several characteristics that differentiate it from ordinary communication links. Most noticeably, the input of the magnetic recording channel is constrained to be binary. This greatly complicates the computation of the ultimate transmission limit, i.e. capacity.

For the much simpler problem of computing the information rate, i.e. the average mutual information, between the input and the output, an algorithm has recently been developped.

In the report period, this algorithm was investigated on different classes of finite-state channels.

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Keywords: Magnetic Recording, Information Rates

Supported by: IBM Research, Zurich Research Lab.

In Collaboration with: Dr. E. Eleftheriou, IBM Research, Zurich Research Lab.

## Digital Signal Processing

### Nonlinear Functions for Blind Separation and Equalization

Under the most general conditions, i.e., when second-order methods fail to work, nonlinear functions are an important part of algorithms solving blind problems such as blind separation and blind equalization. Roughly speaking, they take over the role of a proper training reference signal, which is not available, hence the term blind. The common idea shared by stochastic gradient-search algorithms to either separate or deconvolve signals (or both) is the cross-correlation of signals before and after a nonlinear function, which reveals any existing higher-order correlation among the signals or among different time-lags of the same signal. Such higher-order correlations indicate dependence, which is then formed to an error signal to drive the output signals into a state of higher independence. The underlying higher-order statistics are implicitly produced by nonlinear functions. These nonlinear function are essentially defined by the probability density function of the original source signals to extract and on the cost function (such as independence, maximum-likelihood, and so on). In cases where the original distributions are unknown, change over time, or are of different nature within the source signals, the nonlinearity has to adapt itself according to some estimate of the distribution, or be robust enough to cover a wide mismatch of the assumed

model. Stability regions for different nonlinearities are derived and presented. Although the exact form of the nonlinearity might not matter for an algorithm to converge, it may have an impact on the convergence time or the separation/deconvolution performance. This impact of different nonlinearities is investigated, and robust, optimal, and universal nonlinearities are presented. Moreover, if complexity is an issue, simple nonlinearities are preferable to nonlinearities employing hyperbolic or polynomial functions. The threshold nonlinearity is such a simple nonlinearity, which works for sub-Gaussian signals such as typically used in digital data communications. Moreover, by adjusting the threshold, it may be used to separate and deconvolve any non-Gaussian signal.

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Professor: Prof. Dr. Hans-Andrea Loeliger

Keywords: Blind Separation, Blind Equalization, Nonlinear Functions

**Auditory Scene Analysis for Noise Reduction in Hearing Aids**

The human auditory system has the amazing ability to detect and recognise simultaneous sound sources in a complex acoustic mixture (auditory scene analysis), which is an important precondition for speech intelligibility in noisy situations. Because hearing aid users lack this ability, they have great difficulties in various situations to focus on their conversational partner and blind out the disturbances. This project aims at restoring this lost ability with the help of signal processing. We try to gain a better understanding of the principles underlying (monaural) auditory source separation from a technical viewpoint as well as a way to derive applicable speech enhancement algorithms for hearing aids.

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Keywords: auditory scene analysis, source separation, noise reduction, speech enhancement

Supported by: KTI, Phonak AG

In Collaboration with: Dr. Stefan Launer, Phonak AG

**Model-Based Step-Size Control for Adaptive Filters**

In this project, a model-based approach to computationally efficient adaptive filters operating in a nonstationary environment is considered. In tracking an unknown time-varying system it is important to immediately detect an occasional mismatch between the system and the model. A new detection measure has been found that tracks the signs of the filter update terms. It can be shown that, under certain assumptions, this measure is physically related to the step size of the adaptive filter. For computational reasons, an optimum (minimum-variance) adaptive filter, such as the Kalman filter, has to be simplified to an LMS (Least Mean-Square)-like adaptive filter. However, an optimum step-size control for the LMS filter still requires the recursive update of a matrix (with dimension equal to

the number of filter coefficients). By introducing a new parameter that is only dependent on the input-signal statistics this computational drawback has been overcome. Together with the sign-based detection measure for system changes, several useful step-size controls for nonstationary environments were developped and tested in extensive simulations.

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Professor: Prof. Dr. Hans-Andrea Loeliger

Keywords: nonstationary environment, adaptive FIR filters, Kalman filter, acoustic echo cancellation

Supported by: ETH

In Collaboration with: Dr. A. N. Kaelin

**Binaural Methods for Speech Enhancement in Hearing Aids**

Binaural information i.e. the signals from both ears are used by the auditory system to localize and in turn to separate simultaneous sound sources in complex acoustic scenes. The ability to focus on one source and thus enhance speech intelligibility is known as cocktail party effect. Hearing disabled individuals have partially lost binaural capabilities. The aim of this project is to develop binaural methods — incorporating two sensors — which enhance speech intelligibility in complex acoustic conditions. Both, signal processing methods and processing strategies derived from the auditory system will be utilized.

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Professor: Prof. Dr. Hans-Andrea Loeliger

Keywords: binaural, speech enhancement, noise reduction, beamforming, source separation, hearing aid, cocktail party effect

Supported by: KTI, Phonak AG

In Collaboration with: Dr. Stefan Launer, Phonak AG

**Prediction of local winds with neural networks**

Weather prediction has always been a dream of mankind. In contrast to the success of the meso and large-scale prediction of the atmosphere during the last decades, little progress was made for small scale (or local) prediction. The main reason for this is the chaotic nature of the leading small scale terms in the governing equations of the atmosphere. As a consequence, numerical methods dealing with these terms tend to behave in an unstable manner and many statistical assumptions about the small scale behaviour are found to be inaccurate.

The goal of this project is to improve the prediction of local winds which are strongly influenced by small scale phenomena. For this purpose, several neural networks are under investigation. Neural networks are nonlinear function approximators that require no mathematical model and no prior assumptions of the underlying process.

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Professor: Prof. Dr. Fritz Eggimann

Keywords: nonlinear signal processing, neural networks, local wind prediction

Supported by: MeteoSwiss

In Collaboration with: Dr. N.B. Karayiannis, The University of Houston, Houston, Texas, USA

## Analog Signal Processing

### Design of Analog VLSI Iterative Decoders (DAVID)

This joint research project by the signal processing group of Prof. Dr. H.-A. Loeliger and Prof. em. Dr. G.S. Moschytz and the information theory group of Prof. em. Dr. J.L. Massey aims at developing an analog VLSI design technique for the iterative decoding of error-correcting codes. It is motivated by some recent developments both in analog VLSI (bio-inspired networks) and in coding theory (turbo coding) that suggest the possibility of building analog VLSI decoders that are much more efficient compared to traditional digital VLSI decoders in terms of operating speed and/or power consumption.

The main challenge of this project was to identify suitable computational primitives (elementary circuits) on the transistor level. This first goal was achieved in the first year of the project: a "natural" mapping of the sum-product algorithm onto transistor circuits was found that applies, in particular, to turbo codes, to conventional trellis codes, and to low-density parity check codes. These circuits reveal an interesting connection between semiconductor physics and probability theory. The proof of concept was established by building a demonstration unit for a small binary trellis code using discrete transistors. Swiss and international patent applications have been filed.

Two major test chips have been designed and fabricated so far. They both confirmed to a large extent the theoretical low-power and high-speed operation, although several practical issues have been identified. These issues are mainly related to the very high-speed operation of the circuits and can potentially be solved by the same techniques that are used in the latest generation of digital processors. The focus on last year's research was mainly on the qualitative and quantitative analysis of random mismatch errors in respect to the behaviour of analog-VLSI iterative decoders built in silicon. A simple formulation for the propagation of random transistor mismatch and other non-idealities in transistors has been found. The results have been integrated into system-level simulation framework in order to predict the behaviour of analog decoders before the actual transistor-level design.

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Professor: Prof. Dr. Hans-Andrea Loeliger

Keywords: error-correcting codes, analog signal processing, analog VLSI, bio-inspired circuits

Supported by: Swiss National Science Foundation

In Collaboration with: Prof. em. Dr. G.S. Moschytz; Prof. em. Dr. J.L. Massey; Endora Tech AG, Basel

**CMOS Building Blocks for Analog Decoders**

This project was started to study the behaviour of different configurations of analog decoding circuits using the standard CMOS technology operating in the so called weak-inversion or sub-threshold region. We determined that small building blocks of the size of a single, fully bi-directional 3-port soft-XOR or soft-EQUAL gate would be ideally suited for this purpose. Furthermore, it was decided that these building blocks would also be used for undergraduate student labs. Therefore much emphasis was attributed to a fool-proof and universal design of these building blocks.

Two 3-way soft-logic gates (soft-XOR and soft-EQU) have been designed and fabricated in the Philips C175 CMOS technology using the transistor arrays of Microdul AG, Zurich. This approach is ideally suited for small to medium quantities of rather small chips since only 2 metal masks have to be custom made. A small sample of 200 chips each was packaged in PDIP packages for the use by various researchers and students.

First measurement results indicate that single modules exhibit a precision in the current domain of at least 5 to 7 bits. During the PPS (project, practica and seminars) student labs, a considerable number of different implemenetation of analog decoding circuits will be built. The results of these experiments will be used as the empirical basis to adjust the theoretical simulation results described in the summary of the project DAVID.

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Keywords: error-correcting codes, analog VLSI, sub-threshold CMOS

**Fingerprint Recognition Using Cellular Neural Networks**

Personal identification by fingerprint recognition is a particularly interesting and challenging task in the area of image processing and pattern recognition. Fingerprint-based recognition systems are usually used for criminal identification and police work. But recently, with the increasing power of computers and scanners, research on fingerprint-based recognition systems for civilian applications is becoming increasingly attractive.

A very promising method to be used for fingerprint-based personal identification in civilian applications makes use of the pattern-recognition capabilities of Cellular Neural Networks(CNNs). CNNs belong to the class of nonlinear, recurrent, dynamic, and analog systems. They carry out complex nonlinear signal processing in parallel. Their local connectivity and analog operation make them very suitable for VLSI implementation requiring low power consumption. This means that they provide the possibility of implementing a fingerprint-based recognition system on one chip.

This project is aimed at developing robust CNN algorithms for fingerprint recognition. To this end, we first presented a CNN algorithm which accomplishes the Image-Preprocessing stage in fingerprint recognition. It improves the contrast of an original gray-scale noisy fingerprint, sharpens ridges and reduces the high-frequency noise in the original fingerprint, recovers the destroyed connectivity in the ridges, thus enhancing the fingerprint ridges, and transforms the original fingerprint image into a binary image. Finally, it reduces the width of ridges to one pixel. We have also developed a CNN Fingerprint Feature-Extraction Algorithm. It is able to extract almost genuine ridge endings, ridge bifurcations, and their corresponding direction attributes in a thinned fingerprint, and at the same time to almost completely eliminate the spurious endings and bifurcations which may result from a noisy original fingerprint and from the previous processing operations. In addition, we have investigated the capability of CNNs for realizing image rotation which, in the area of pattern recognition, belongs to the field of so-called global problems. In this connection, a new concept for rotating a black/white image by using CNNs has been developed. It will be useful for the CNN-based matching of two distinct fingerprints.

Presently, the capability of CNNs for Fingerprint Matching is being investigated. Fingerprint features obtained by employing our CNN Fingerprint Feature-Extraction Algorithm will be used to compare a fingerprint to be recognized with the fingerprints in a database. Our system will then be compared with other recognition systems based on digital processing techniques.

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Professor: Prof. Dr. Hans-Andrea Loeliger

Keywords: fingerprint recognition, cellular neural networks, image enhancement, feature extraction, feature matching

In Collaboration with: Prof. em. Dr. G.S. Moschytz

# 3.3 Completed Research Projects

MATHIS Heinz

**Nonlinear Functions for Blind Separation and Equalization**

ETH-Diss. Nr. 14313 (Referee: Prof. Dr. H.-A. Loeliger)

Nonlinear functions are an important part of blind adaptive algorithms solving filtering problems such as blind separation and blind equalization. Roughly speaking, they take over the role of a proper training reference signal, which is not available, hence the term "blind".

The common idea shared by stochastic gradient-search algorithms either separating or deconvolving signals (or both) is to cross-correlate the signals before and after a nonlinear function, which reveals any existing higher-order correlation among the signals or among different time lags of the same signal. Such higher-order correlations indicate mutual dependence, which is then formed into an error signal to drive the output signals toward a state of higher independence. The underlying higher-order statistics are implicitly produced by the nonlinear functions. These nonlinear functions are essentially defined by the probability density function of the original source signals to extract and the cost function (such as mutual independence, maximum-likelihood, etc.).

In cases where the original distributions are unknown, change over time, or are of different nature, the nonlinearity has to adapt itself according to some estimate of the distribution, or be robust enough to cover a wide mismatch of the assumed model. Stability analyses reveal the stable regions of nonlinearities by determining the set of distributions for which a given nonlinearity results in local separation convergence. Unfortunately, no fixed nonlinearity can cover the entire universe of distributions.

Although the exact form of the nonlinearity might not matter for an algorithm to converge, it may have an impact on the convergence time of the separation/deconvolution process. By investigating these stability and performance parameters, robust, optimal, and universal (parametric) nonlinearities can be found. If complexity is an issue, simple nonlinearities are preferable to nonlinearities employing hyperbolic or polynomial functions. The threshold nonlinearity is such a simple nonlinearity. It works directly for sub-Gaussian signals such as typically used in digital data communications. Moreover, by adjusting the threshold, it may be used to separate any non-Gaussian signal.

Bias removal techniques, which remove any coefficient bias due to additive noise, are applicable to the threshold nonlinearity. The threshold nonlinearity is also well suited to blind equalization and blind carrier phase synchronization, a technique that is related to blind signal separation, and can hence be described within a common framework.

On the other hand, many simple algorithms for blind deconvolution, such as Sato's algorithm and the constant-modulus algorithm (CMA) can be extended to work

for a wider class of distributions by adding a simple coefficient norm factor in the update equation.

LIPPUNER Daniel

**Model-Based Step-Size control for Adaptive Filters**

ETH-Diss. Nr. 14461 (Referee: Prof. Dr. H.-A. Loeliger)

Adaptive digital filters are filters whose parameters are continually adjusted according to some performance criterion. In many applications, such as signal processing, communications, and control, there is no information available about the (possibly time-varying) environment statistics. In these cases, the performance of adaptive filters often make them an attractive alternative to fixed digital filters.

The adjustment of the filter parameters is governed by an adaptive algorithm. *Stochastic-gradient* adaptive algorithms, whose best known representative is the *Least-Mean-Square* (LMS) algorithm with a fixed step size, perform parameter estimates that converge only in the mean to a steady-state solution. The choice of this step size is a trade-off between steady-state error (small step size) and tracking capability (large step size). If certain *a priori* assumptions about the environment statistics are considered, improved parameter estimates can be obtained by so-called *model-based* adaptive algorithms. The Kalman filter is such a model-based adaptive algorithm, in which these assumptions are mathematically formulated in a state-*space model*. If the state-space model coincides with the real-world behavior, optimum parameter estimates can be obtained.

In most practical applications, where the environment statistics are nonstationary, it is a complex task to continuously accommodate the filter to the changing circumstances and achieve a reliable model-based parameter estimate. Further, model-based adaptive algorithms are computationally much more expensive than their stochastic-gradient counterparts. For these reasons, stochastic-gradient adaptive algorithms have often been the preferred choice.

This thesis combines the advantages of the two types of algorithms. The Kalman filter is reformulated under the constraint that it contains only scalar recursive update equations for a (nearly optimum) scalar step size. The resulting model-based *step-size control* inherently takes into account the statistics of the filter excitation signal. As a consequence, a considerable performance improvement over existing types of such scalar step-size algorithms can be achieved, particularly in the case of highly correlated excitation signals.

To apply an appropriate step-size control in a nonstationary environment, a *cross-correlation measure*, that indicates a mismatch between the model and the real-world behavior, becomes necessary. A new cross-correlation measure that corresponds to a normalized form of the so-called *excess mean squared error* of the adaptive filter is introduced. It is based on the signs of the filter update terms and can be analytically (rather than only heuristically) incorporated into the inherent state-space model of a step-size control.

In the context of acoustic echo cancellation, where the adaptive filter has to estimate the undesired echo path from the loudspeaker back to the microphone, the performance of the discussed algorithms is verified by extensive simulations.

## 3.3 Completed Dissertations

MATHIS Heinz — Nonlinear Functions for Blind Separation and Equalization

*ETH Diss. Nr. 14313*
Referee: Prof. Dr. H.-A. Loeliger
Co-referee: Prof. Dr. S.C. Douglas, SMU Dallas

LIPPUNER Daniel — Model-Based Step-Size Control for Adaptive Filters

*ETH Diss. Nr. 14461*
Referee: Prof. Dr. H.-A. Loeliger
Co-referee: Prof. Dr.-Ing. E. Haensler, TU Darmstadt
Dr. Kaelin A.

# 4. Congresses, Meetings and Committees

## 4.1 Congress Organization

**Prof. Lapidoth**

Member Program Committee, 2001 IEEE International Symposium on Information Theory, Washington, USA.

Co-Chair Program Committee, 2002 IEEE International Symposium on Information Theory, Lausanne, Switzerland.

## 4.2 Participation in Congresses and Meetings

| | |
|---|---|
| Arnold Dieter | ICC'2001, Helsinki, Finland, 11.-14.6.01. |
| Arnold Dieter | Research Stay with Harvard University, Cambridge, MA, USA, 30.6.-30.7.01. |
| Gao Qun | ISCAS'2001, The IEEE International Symposium on circuits and Systems, Sydney, Australia, 6.-9.5.01. |
| Gao Qun | ECCTD'01, European Conference on Circuit Theory and Design, Espoo, Finland, 28.-31.8.01. |
| Heutschi Kurt | DAGA, Hamburg, Germany, Germany, 26.-30.3.01. |
| Heutschi Kurt | Inter-Noise 2001, Den Haag, Holland, 27.-30.8.01. |
| Hofbauer Markus | Industry Project with Phonak AG, Staefa, Switzerland, 1.1.-31.3.01. |
| Hofbauer Markus<br>Korl Sascha | Seminar on "Sound Classification", Phonak AG, Staefa, Switzerland, 21.6.01. |
| Hofbauer Markus<br>Korl Sascha | Seminar on "Signalverarbeitung für hochgradig Schwerhörige", Phonak AG, Staefa, Switzerland, 29.10.01. |
| Kretzschmar Ralf | 2. Forschungskolloquium 2001 der MeteoSchweiz, Zuerich, Switzerland, 28.11.01. |
| Lapidoth Amos | TPC Meeting ISIT 2001, Technion Haifa, Israel, 24.1.01. |
| Lapidoth Amos | Seminar über Statistik, ETH Zurich, Switzerland, 11.5.01. |
| Lapidoth Amos | IBM Rüschlikon, Switzerland, 11.6.01. |
| Lapidoth Amos<br>Moser Stefan | 2001 Int. Symposium on Information Theory ISIT 2001, Washington, USA, 24.-29.6.01. |
| Lapidoth Amos | Summer Research Institute 2001, EPF Lausanne, Switzerland, 2.-21.7.01. |
| Lapidoth Amos | 2001 IEEE ITW Workshop, Cairns, Australia, 31.8.-9.9.01. |
| Lapidoth Amos | The Chinese University of Hong Kong,China, 12.-13.9.01. |
| Lapidoh Amos | What Is Information Workshop, Ben-Gurion University, Sde Boker, Israel, 17.-21.12.01. |
| Lippuner Daniel | IWAENC'01, International Workshop on Acoustic Echo and Noice Control, Darmstadt, Germany, 10.-13.9.01. |
| Lippuner Daniel | FTW-Kolloquium, (Forschungszentrum Telekommunikation Wien), Vienna, Austria, 5.10.01. |
| Loeliger Hans-Andrea | Workshop on Statistical Physics and Capacity-Approaching codes, Trieste, Italy, 21.-25.5.01. |

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| Loeliger Hans-Andrea | IEEE International Symposium on Information Theory, Washington DC, USA, 24.-29.6.01. |
| Loeliger Hans-Andrea | IEEE Information Theory Workshop, Cairns, Australia, 2.-7.9.01. |
| Loeliger Hans-Andrea | Workshop on A/D Converters for Telecommunications, Pfaeffikon, Switzerland, 22.10.01. |
| Lustenberger Felix | ISCAS'2001, Sydney, Australia, 6.-9.5.01. |
| Mathis Heinz | SPAWC 2001 Signal Processing Advances in Wireless Communications, Taoyuan, Taiwan, 20.-23.3.01. |
| Mathis Heinz | ICASSP 2001 International Conference on Acoustics, Speech, and Signal Processing, Salt Lake City, UT, USA, 7.-11.5.01. 2001. |
| Mathis Heinz | Research Stay with Southern Methodist University Dallas, TX, USA, 14.5.-21.7.01. |
| Mathis Heinz | ICECS 2001, IEEE International Conference on Electronics, Circuits, and Systems, Malta, 2.-5.9.01. |
| Merkli Patrick | Workshop A/D Converters for Telecommunications, Pfaeffikon, Switzerland, 22.10.01. |
| Vontobel Pascal | IEEE International Symposium on Information Theory, Washington, DC, USA, 24.-29.6.01. |
| Vontobel Pascal | Research Stay with University of Notre Dame, South Bend, IN, USA, 3.7.-31.8.01. |
| Vontobel Pascal | IEEE Information Theory Workshop, Cairns, Australia, 2.-7.9.01. |
| Vontobel Pascal | DIMACS Workshop on Codes and Complexity, Piscataway, NJ, USA, 4.-7.12.01. |
| Vontobel Pascal | Research Stay with Forschungszentrum Telekommunikation Wien (FTW), Vienna, Austria, 13.-18.12.01. |

# 4.3 Service Activities and Society Memberships

**Prof. Lapidoth**

Senior Member of the IEEE New York

Member of Search Committee for the Professorship in Wireless Communications, ETHZ

**Prof. Loeliger**

Member of IEEE

Chairman of the IEEE Switzerland Chapter on Digital Communication Systems

**Dr. Lustenberger**

Member of the Analog Signal Processing Technical Committee (ASPTC) of IEEE Circuits and Systems (CAS) Society.

**Dr. Heutschi**

Member, Acoustical Society of America

Member, Audio Engineering Society

Member, Swiss Acoustical Society (SGA)

## 4.4 Presentations by Institute Members

| | |
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| Arnold Dieter | "On the Information Rate of Binary-Input Channels with Memory", ICC'2001, Helsinki, Finland, 14.6.01. |
| Gao Qun | "Fingerprint Recognition Using CNNs: Fingerprint Preprocessing", ISCAS'2001, Sydney, Australia, 8.5.01. |
| Gao Qun | "Fingerprint Feature Extraction using CNNs", ECCTD'01, Espoo, Finland, 29.8.01. |
| Heutschi Kurt | "Validierung von Eisenbahnlärmmodellen in einer Talsituation anhand einer Langzeitmessung", DAGA, Hamburg, Germany, 27.3.01. |
| Heutschi Kurt | "New Swiss Source Model for Road Traffic Noice", Inter-Noise 2001, Den Haag, Holland, 28.8.01. |
| Lapidoth Amos | "Multi-Antennas for Fading Channels", ETH Zurich, Switzerland, 30.1.01. |
| Lapidoth Amos | "A Dual Expression for Channel Capacity and Applications", Seminar für Statistik, ETH Zürich, Switzerland, 11.5.01. |
| Lapidoth Amos | "On the Shannon Capacity of Multi-Antenna Systems for Flat Fading Channels", IBM Rüschlikon, Switzerland, 11.6.01. |
| Lapidoth Amos<br>Cohen Aaron | "The Capacity of the Vector Gaussian Watermarking Game", ISIT 2001, Washington, USA, 24.-29.6.01. |
| Lapidoth Amos<br>Moser Stefan | "Convex-Programming Bounds on the Capacity of Flat Fading Channels", ISIT 2001, Washington, USA, 24.-29.6.01. |
| Lapidoth Amos | "On the Shannon Capacity of Multi-Antenna Systems for Flat Fading Channels", Summer Research Institute, EPF Lausanne, Switzerland, 11.7.01. |
| Lapidoth Amos<br>Moser Stefan | "On the Fading Number of Multi-Antenna Systems", 2001 Workshop on Information Theory, Cairns, Australia, 2.-7.9.01. |
| Lapidoth Amos | "On the Shannon Capacity of Multi-Antenna Systems for Flat Fading Channels", The Chinese University of Hong Kong, China, 13.9.01. |
| Lapidoth Amos | "A Dual Expression for Channel Capacity and Applications", Workshop: What is Information?, Ben-Gurion University, Sde Boker, Israel, 18.12.01. |
| Lippuner Daniel | "Model-Based Step-Size Controls for Adaptive Filters", Colloquia FTW, Vienna, Austria, 5.10.01. |

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| Lippuner Daniel | "Model-Based Step-Size Control for Adaptive Filters", ETH Zurich, Switzerland, 17.10.01. |
| Loeliger Hans-Andrea | "Markov-Modelle und Vorwärts-Rückwärts-Algorithmen", Einführungsvorlesung an der ETHZ, Zurich, Switzerland, 9.5.01. |
| Loeliger Hans-Andrea | "Analog Decoding and Beyond", IEEE Information Theory Workshop, Cairns, Australia, 2.-7.9.01. |
| Loeliger Hans-Andrea | "On Hybrid Factor Graphs and Adaptive Equalization", IEEE Int. Symposium on Information Theory, Washington DC, USA, 24.-29.6.01. |
| Loeliger Hans-Andrea | "Graphical Models and Signal Processing", FORUM DIDEROT — Mathematics and Communications, EPFL, Lausanne, Switzerland, 22.-23.11.01. |
| Lustenberger Felix | "On Mismatch Errors in Analog-VKSU Error correcting Decoders", ISCAS'01, Sydney, Australia, 7.5.01. |
| Mathis Heinz | "On the Kurtosis of Digitally Modulated Signals with Timing Offsets", SPAWC 2001, Taoyuan, Taiwan, 21.3.01. |
| Mathis Heinz | "Unbiased Blind Separation Using the Threshold Nonlinearity", SPAWC 2001, Taoyua, Taiwan, 22.3.01. |
| Mathis Heinz | "On Optimal and Universal Nonlinearities for Blind Signal Separation", ICASSP 2001, Salt Lake City, UT, USA, 11.5.01. |
| Mathis Heinz | "A Proof of the Non-existence of Universal Nonlinearities for Blind Signal Separation", ICECS 2001, Malta, 5.9.01. |
| Mathis Heinz | "Blind Equalization of Impulsive Signals", ABB Corporate Research Center", Baden-Daettwil, Switzerland, 25.9.01. |
| Vontobel Pascal | "An Upper Bound on the Capacity of Channels with Memory and Constraint Input", IBM Labs, Rueschlikon, Switzerland, 20.6.01. |
| Vontobel Pascal | "Constructions of Regular and Irregular LDPC Codes Using Ramanujan Graphs and Ideas from Margulis", IBM Labs, Rueschlikon, Switzerland, 20.6.01. |
| Vontobel Pascal | "An Upper Bound on the Capacity of Channels with Memory and Constraint Input", Bell Labs, Murray Hill, NJ, USA, 2.7.01. |
| Vontobel Pascal | "Constructions of Regular and Irregular LDPC Codes Using Ramanujan Graphs and Ideas from Margulis", University of Illinois at Urbana-Champaign (UIUC), IL, USA, 13.8.01. |
| Vontobel Pascal | "On the Construction of Regular and Irregular LDPC Codes Based on Graphs with Large Girth", University of Melbourne, Australia, 14.9.01. |

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| Vontobel Pascal | "Upper and Lower Bounds on the Capacity of Channels with Memory and Constraint Input", Harvard University, Cambridge, MA, USA, 30.11.01. |
| Vontobel Pascal | "On Algebraic Code Constructions for Iterative Decoding", DIMACS Workshop on Codes and Complexity, Piscataway, NJ, USA, 6.12.01. |
| Vontobel Pascal | "From Graphs with Large Girth to LDPC and Turbo Codes", Forschungszentrum Telekommunikation Wien (FTW), Vienna, Austria, 17.12.01. |

## 4.5 Organization of Lectures, Seminars, and Colloquia

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

**Invited by Prof. Lapidoth:**

09.07.01 **Prof. Sergio Verdú,** Dept. Electrical Engineering, Princeton University, Princeton, USA,
"Spectral Efficiency in the Power-Limited Regime".

**Invited by Prof. Loeliger:**

16.08.01 **Prof. Scott Douglas,** Dept. Electrical Engineering, Southern Methodist University, Dallas, USA,
"Acoustic Blind Source Separation without Temporal Deconvolution".

28.08.01 **Benjamin Vigoda,** MIT Cambridge, USA,
"Noise Locked Loops: A Nonlinear Dynamic System for Spread Spectrum Acquisition.

15.11.01 **Tuechler Michael, M.S.,** Visiting Scientist, IBM Research Lab.,
"Linear Equalization using A-priori Information".

17.12.01 **Prof. Dr.-Ing. E. Hänsler,** TU Darmstadt, Germany,
"Implementierung einer Optimalen Schrittweite für ein adaptives Filter zur Reduktion akustischer Echos".

**Invited by Dr. Heutschi**

10.01.01 **Barbara Flückiger Körnermann,** Dr., Hochschule für Gestaltung, Zürich Hochschule für Gestaltung, Zürich,
"Soundscapes als Szenographien des Films".

31.01.01 **Eckard Mommertz**, Dr.-Ing., Müller-BBM GmbH, Planegg, Germany,
"Messung, Modellierung und Einsatz der Schallstreuung in der Raumakustik".

09.05.01 **John Storyk,** Principal of Walters-Storyk Design Group (WSDG) – Highland, New York, USA and Liestal, Switzerland
"Recent Trends in Modern audio Production Facility Design".

30.05.01 **Daniel Robert,** Dr. Zoologisches Institut, Uni Zurich, Switzerland
"Hören bei Insekten: Akustik, Biomechanik and auiditorische Oekologie".

# 5. Publications

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|---|---|
| Gao Qun | "Fingerprint Recognition Using CNNs: Fingerprint Preprocessing", Proceedings of the IEEE International Symposium on Circuits and Systems (ISCAS'2001), Sydney, Australia, vol. 3, pp. 433-436, May 2001. |
| Gao Qun | "Fingerprint Feature Extraction Using CNNs", Proceedings of the 15th European Conference on Circuit Theory and Design (ECCTD'01), Espoo, Finland, vol. 1, pp. 97-100, August 2001. |
| Wunderli Jean Marc<br>Heutschi Kurt | "Simulation Model for Sonic Boom of Projectiles", Acta Acustica, 2001, vol. 87, pp. 86-90. |
| Wunderli Jean Marc<br>Heutschi Kurt | "Shielding Effect for Sonic Boom of Projectiles", Acta Acustica 2001, vol. 87, pp. 91-100. |
| Eggenschweiler Kurt<br>Lüthi-Freuler Nicole<br>Heutschi Kurt | "Optimaler Lärmschutz dank akustischer Modellmessung", Tec21, Heft 7, 2001. |
| Bräunlich R.<br>Teich T.<br>Weber H.J.<br>Heutschi Kurt | "Reduktionsmassnahmen für Koronaschall-Emissionen an Hochspannungsfreileitungen", Bulletin SEV/VSE Nr. 18, 2001. |
| Hofbauer Markus | "Noise Reduction: Analysis of Common Onsets and Aplitude Modulation Spectra; Best-case Spectral Substraction", Internal Report Phonak AG, p. 41, August 2001. |
| Cohen Aaron<br>Lapidoth Amos | "The Capacity of the Vector Gaussian Watermarking Game", Proceedings IEEE Int. Symposium on Information Theory, Washington, USA, p. 5, June 2001. |
| Lapidoth Amos<br>Moser Stefan | "Convex-Programming Bounds on the Capacity of Flat Fading Channels", Proceedings IEEE Int. Symposium on Information Theory, Washington, USA, p. 52, June 2001. |
| Lapidoth Amos<br>Moser Stefan | "On the Fading Number of Multi-Antenna Systems", Proceedings 2001 Workshop on Information Theory, Cairns, Australia, September 2001. |
| Lippuner Daniel | "A Step-Size Control for Adaptive Filters Using a Sign-Based Estimation of the Normalized Excess Mean-Squared Error", Proceedings of the International Conference on Electronics, Circuits and Systems (ICECS'01), Malta, vol. III, pp. 1165-1170, September 2001. |

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|---|---|
| Lippuner Daniel | "An Improved Step-Size Control for LMS Filters with Correlated Input Signals", Proceedings of the International Workshop on Acoustic Echo and Noise Control IWAENC'01), Darmstadt, Germany, pp. 83-86, September 2001. |
| Lippuner Daniel | "Model-Based Step-Size Control for Adaptive Filters", Dissertation, Hartung-Gorre Verlag, Konstaz, Series in Signal and Information Processing, ISBN 3-89649-755-3, pp. 160, January 2002. |
| Kschischang F.R.<br>Frey B.J.<br>Loeliger Hans-Andrea | "Factor Graphs and the Sum-Product Algorithm", IEEE Transactions on Information Theory, vol. 47, pp. 498-519, February 2001. |
| Loeliger Hans-Andrea<br>Lustenberger Felix<br>Helfenstein Markus<br>Tarköy Felix | "Probability Propagation and Decoding in Analog VLSI", IEEE Transactions on Information Theory, vol. 47, pp. 837-843, February 2001. |
| Lustenberger Felix<br>Loeliger Hans-Andrea | "On Mismatch Errors in Analog-VLSI Error Correcting Decoders", Proceedings IEEE International Symposium on Circuits and Systems, Sydney, Australia, vol. 4, pp. 198-201, May 2001. |
| Arnold Dieter<br>Loeliger Hans-Andrea | "On the Information Rate of Binary-Input Channels with Memory", Proceedings IEEE Int. Conference on Communications, Helsinki, Finland, pp. 2692-2695, June 2001. |
| Loeliger Hans-Andrea | "On Hybrid Factor Graphs and Adaptive Equalization", Proceedings IEEE Int. Symposium on Information Theory, Washington DC, USA, p. 268, June 2001. |
| Loeliger Hans-Andrea | "Analog decoding and beyond", Proceedings IEEE Information Theory Workshop, Cairns, Australia, pp. 126-127, September 2001. |
| Mathis Heinz | "On the Kurtosis of Digitally Modulated Signals with Timing Offsets", Signal Processing Advances in Wireless Communications SPAWC 2001, Taoyuan, Taiwan, pp. 86-89, March 2001. |
| Mathis Heinz<br>Joho Marcel | "Unbiased Blind Separation Using the Threshold Nonlinearity", Signal Processing Advances in Wireless Communications SPAWC 2001, Taoyuan, Taiwan, pp. 239-242, March 2001. |
| Mathis Heinz<br>Douglas S.C. | "On Optimal and Universal Nonlinearities for Blind Signal Separation", IEEE International Conference on Acoustics, Speech, and Signal Processing, ICASSP 2001, Salt Lake City, UT, USA, pp. 2777-2780, May 2001. |

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| Joho Marcel<br>Lambert R.H.<br>Mathis Heinz | "Elementary Cost Functions for Blind Separation of Non-Stationary Source Signals", IEEE International Conference on Acoustics, Speech, and Signal Processing, ICASSP 2001, Salt Lake City, UT, USA, pp. 2793-2796, May 2001. |
| Mathis Heinz<br>von Hoff Thomas<br>Joho Marcel | "Blind Separation of Signals with Mixed Kurtosis Signs Using Threshold Activation Functions", IEEE Transactions on Neural Networks, vol. 12, No. 3, pp. 618-624, May 2001. |
| Joho Marcel<br>Mathis Heinz<br>Moschytz George S. | "Combined Blind/non-Blind Source Separation Based on the Natural Gradient", IEEE Signal Processing Letters, vol. 8, No. 8, pp. 236-238, August 2001. |
| Mathis Heinz | "A Proof of the Non-existence of Universal Nonlinearities for Blind Signal Separation", IEEE International Conference on Electronics, Circuits, and Systems, ICECS 2001, Malta, pp. 1265-1268, September 2001. |
| Mathis Heinz | "Nonlinear Functions for Blind Separation and Equalization", Hartung-Gorre Verlag, Konstanz, Series in Signal and Information Processing, ISBN 3-89649-728-6, November 2001. |
| Mathis Heinz | "Blind Phase Synchronization for VSB Signals", IEEE Transactions on Broadcasting, vol. 47, no. 4, pp. 340-347, December 2001. |
| Lambert R.H.<br>Joho Marcel<br>Mathis Heinz | "Polynomial Singular Values for Number of Wideband Sources Estimation and Principal Component Analysis", Proc. Third Int. Conference on Independent Component Analysis and Blind Source Separation, ICA 2001, San Diego, CA, USA, pp. 379-383, December 2001. |
| Schaerer Thomas | "Soviel wie nötig – so wenig wie möglich: Einfach realisierbar Vierkanal-Ubersteuerungsanzeige", MEGALINK 3/01, p. 34, March 2001. |
| Schmid Hanspeter | "An 8.25-MHz 7th-Order Bessel Filter Built with Single-Amplifier Biquadratic MOSFET C Filters", Analog Integrated Circuits and Signal Processing, vol. 30, no. 1, pp. 69-81, January 2002. |
| Schmid Hanspeter | "The Current-Feedback OTA",Proceedings of the ISCAS, Sydney, Australia, May 2001, vol. 1, pp. 655-658, May 2001. |
| Schmid Hanspeter | "Theory and Practice - Thinking Styles in Engineering and Science", Australian Journal on Information Systems, special issue on knowledge management, pp. 106-115, December 2001. |

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| Rosenthal J.<br>Vontobel Pascal | "Constructions of LDPC Codes Using Ramanujan Graphs and Ideas from Margulis", Proceedings of the 38-th Allerton Conference on Communication, Control, and Computing, Monticello, Illinois, USA, pp. 69-81, October, 2001. |
| Rosenthal J.<br>Vontobel Pascal | "Construction of Regular and Irregular LDPC Codes Using Ramanujan Graphs and Ideas from Margulis", IEEE International Symposium on Information Theory, Washington, DC, USA, p. 4, June 2001. |
| Vontobel Pascal<br>Tanner R.M. | "Construction of Codes Based on Finite Generalized Quadrangles for Iterative Decoding", IEEE Intern. Symposium on Information Theory, Washington, DC, USA, p. 223, June 2001. |
| Vontobel Pascal<br>Arnold D.M. | "An Upper Bound on the Capacity of Channels with Memory and Constraint Input", IEEE Information Theory Workshop, Cairns, Australia, pp. 147-149, September 2001. |
| Zennaro Daniel<br>Wellig Peter<br>Läubli Thomas<br>Moschytz George S.<br>Krueger H. | "A Decomposition Software Package for the Decomposition of Long-term Multi-channel Electromyographic Signals", Proceedings of the 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Istanbul, Turkey, October 2001. |
| Zennaro Daniel<br>Läubli Thomas<br>Wellig Peter<br>Schnoz Michael<br>Krebs D.<br>Klipstein A.<br>Krueger H. | "Recruitment of Low Threshold Motor Units in the Human Trapezius Muscle during Computer Tasks", Proceedings of the Fourth International Scientific Conference on Prevention of Work-Related Musculoskeletal Disorders, Amsterdam, The Netherlands, p. 57, October 2001. |
| Zennaro Daniel<br>Läubli Thomas<br>Wellig Peter<br>Schnoz Michael<br>Krebs D.<br>Klipstein A.<br>Krueger H. | "The Influence of a Wrongly Adjusted Table on the Firing Pattern in the Trapezius Muscle during Finger Tapping", Proceedings of the 9th International Conference on Human-Computer Interaction (HCI), New Orleans Lousiana USA, pp. 360-362, August 2001. |
| Zennaro Daniel<br>Läubli Thomas<br>Wellig Peter<br>Schnoz Michael<br>Krebs D.<br>Klipstein A.<br>Krueger H. | "Recruitment of Low Threshold Motor Units in the Trapezius Muscle during a Ten Minutes Tapping Task", 2nd PROCID Symposium-Prevention of Muscle Disorders in Computer Users: Scientific Basis and Recomendations, Göteborg, (ISBN 91-7045-590-2), Arbeitslivsinstitutet, Göteborg, pp. 180-185, March 2001. |

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| Wellig Peter<br>Loeliger Hans-Andrea<br>Moschytz George S.<br>Zennaro Daniel | "Electromyogram Long-Term Decomposition", In: Kaderfors R., Sandsjö L. (eds): The 2nd PROCID Symposium-Prevention of Muscle Disorders in Computer Users: Scientific Basis and Recomendations, Göteborg, 8-10 March 2001 (ISBN 91-7045-590-2). Arbeitslivsinstitutet, Göteborg, pp. 175-180, March 2001. |

# 6. Guests, Visitors

## 6.1 Activities of Academic Guests at the Institute

**Guests of Prof. Lapidoth:**

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| **Prof. Sanjoy Mitter** | MIT, Cambridge, USA, Lecture Series on "Duality, Bayesian Estimation and Inference on Graphs". | 02.04.-31.05.01 |
| **Prof. Sergio Verdú** | Princeton University, Princeton, USA, presented a talk on "Spectral Efficiency in the Power-Limited Regime". | 06.07.–09.07.01 |
| **Prof. Shlomo Shamai** | Technion Haifa, Israel, presented a talk on "Some Information Theoretic Asects of Multi-Cell Wireless Systems". | 10.11.-12.11.01 |

**Guests of Prof. Loeliger:**

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|---|---|---|
| **Prof. Scott Douglas** | Southern Methodist University Dallas, USA, presented a talk on "Acoustic Blind Source Separation without Temporal Deconvolution". | 14.07.-17.07.01 |
| **Prof. Allen Lindgren** | University of Rhode Island Kingston, USA, "Collaboration with the Adaptive Filter Group". | 01.08.-15.09.01 |
| **Benjamin Vigoda** | MIT Media Lab, Cambridge, USA, held a talk on "Noise Locked Loops: A Nonlinear Dynamic System for Spread Spectrum Acquisition". | 27.08.- 30.08.01 |