

Signal and Information Processing Laboratory

Prof. A. Lapidoth and Prof. H.-A. Loeliger

ANNUAL REPORT

2012

Address: Signal and Information Processing Laboratory
ETH Zurich, Sternwartstr. 7, CH-8092 Zürich

Phone: +41- 44 - 632 2764

Fax: +41- 44 - 632 1208

Electronic mail: sekr@isi.ee.ethz.ch

Web: <http://www.isi.ee.ethz.ch>

Editor: R. Hildebrand

Foreword

It is a pleasure to report that our Institute continues to create a vibrant environment in which our students, permanent staff, faculty, and visitors can thrive. Teaching is as ever a top priority for us, and we spare no effort to offer our students exciting and relevant courses .

In 2012 we also organized (together with the Communication Theory Group) the International Zurich Seminar on Communications, which attracted scientists from all over the world. It was a huge success, intellectually and socially, as a profitable and pleasurable time was had by all.

We have been, and continue to be, blessed with excellent Ph.D. students who are not only accomplished and creative, but also cheerful and pleasant. No wonder, therefore, that it is simultaneously rewarding to witness their accomplishments upon completion of their theses, and yet mourn the end of a close collaboration. Fortunately, however, we will continue to see Dr. Jonas Biveroni and Dr. Christoph Reller, as they shall continue at ETH. We must, however, bid farewell to Dr. Lukas Bolliger, who has our best wishes for a rewarding career (they do exist, even beyond our hallowed halls) and we look forward to seeing him at our future alumni functions. To the newcomers who are in awe of their predecessors' accomplishments, we offer the assurance that our institute is equally committed to their future success.

Amos Lapidot

Contents

FOREWORD	2
CONTENTS	3
1. PERSONNEL	4
2. TEACHING	5
2.1 COURSES	5
2.2 LAB COURSES (PRACTICA)	5
2.3 STUDENT PROJECTS	6
3. RESEARCH	8
3.1 GENERAL RESEARCH AREAS	8
3.2 CURRENT RESEARCH TOPICS	9
3.3 PUBLICATIONS	10
3.4 COMPLETED PROJECTS	12
4. TRIPS AND TALKS	13
4.1 PARTICIPATION IN CONFERENCES AND MEETINGS	13
4.2. PRESENTATIONS BY INSTITUTE MEMBERS NOT LISTED UNDER 3.3	14
4.3 INVITED LECTURES AND SEMINARS	14
5. SERVICE ACTIVITIES	15
5.1. CONFERENCE ORGANIZATION	15
5.2 OTHER SERVICE ACTIVITIES AND SOCIETY MEMBERSHIPS	15

1. Personnel

Professor for Information Theory:

Prof. Amos Lapidot

Professor for Signal Processing:

Prof. Hans-Andrea Loeliger

Secretaries:

Rita Hildebrand

Silvia Tempel

Senior Researcher:

Dr. Nikolai Nefedov

Research Assistants

Jonas Biveroni

Lukas Bolliger

Lukas Bruderer

Christoph Bunte

Sarah Neff

Christoph Reller

Christian Schürch

Georg Wilckens

Jiun-Hung Yu

Dipl.El.Eng.

MSc ETH (left on 29.2.2012)

MSc ETH

MSc ETH

MSc ETH

MSc ETH

MSc ETH

MSc ETH

MSc.NCTU Taiwan

Technical Staff:

Thomas Schärer

Patrik Strebel

El.Eng.HTL

2. Teaching

2.1 Courses

Sem.	Instructors	Title	ETH-No.
5th	Prof. H.-A. Loeliger	Zeitdiskrete und statistische Signalverarbeitung	227-0101
7th	Prof. H.-A. Loeliger	Signal and Information Processing	227-0427
8th	Prof. H.-A. Loeliger	Algebra and Error Correcting Codes	227-0418
7th	Prof. A. Lapidoth	Applied Digital Information Theory I	227-0417
6th	Prof. A. Lapidoth	Communication and Detection Theory	227-0104
8th	Prof. A. Lapidoth	Information Theory II	227-0420

Courses by external Lecturers

7th	Dr. K. Heutschi	Accoustics I	227-0477
8th	Dr. K. Heutschi	Accoustics II	227-0478
8th	Dr. H.P. Schmid	Analog Signal Processing and Filtering	227-0478

2.2 Lab Courses (Practica)

5/6th	Practica	Laboratory for "Fundamentals in Electrical Engineering"	227-0095
3rd/4th	Ch. Schürch	Blackfin DSP	PPS
2nd/3rd	Th. Schaerer	EMG Biofeedback Device	PPS

2.3 Student Projects

Students	Title	Supervisor
Semester Projects FS 2012		
Christopher Mollén	Pulse Detection with Online Likelihood Filtering	Lukas Bruderer Christoph Reller
Nour Zalmai	Parameter Estimation with the Alternating Direction Method of Multipliers	Lukas Bruderer Christoph Reller
Kristoffer O.W. Nordström	Analog-to-Digital Conversion Using Unstable Filters Experimental Circuit	Georg Wilckens Jonas Biveroni
Zuzana Gavorová	Capacity Estimates of Optical Fibers Networks	Amos Lapidoth Christoph Bunte
Chang Wang	Feedback and Cribbing in Multiple-Access Channels with Erasures	Amos Lapidoth Christoph Bunte
Ismail Celebi	Code Construction and Decoding of Polar Codes	Christian Schürch
Danny Luu	Detection of Noisy Pseudo-Periodic Signals	H.-A. Loeliger Christoph Reller Sarah Neff
Semester Projects HS 2012		
Teute Bunjaku Andreas Schwaller	Heart Rate Estimation with a Weighing Scale	Christoph Reller Lukas Bruderer
Sarthak Gupta	Clustering by Gibbs Sampling	Lukas Bruderer Sarah Neff

Master Theses 2012

Dinu Kaufmann	Mode-based Fire Detection with Gas Sensors	Christoph Reller Lukas Bruderer Claudio Fölmi
Annina Bracher	Cribbing, Conferencing, Feedback, and State-Information on the Multiple-Access Channel	Amos Lapidoth
David Sutter	Achieving the Capacity of any DMC using only Polar Codes & Fault-Tolerant Quantum Reed-Muller Coding	Joseph Merrill Renes Frederic Sebastien Dupont-Dupuis Renato Renner Amos Lapidoth
Filipe Barata	Adaptive Filtering with Applications to Force Sensor Signals	Lukas Bruderer Sarah Neff Georg Wilckens
Thomas Laich	The Kaspi/Heegard-Berger Problem with an Informed Encoder	Michèle Wigger Amos Lapidoth

3. Research

3.1 General 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:

- Combined source-channel coding for multi-access networks
- Multi-access channels with noisy feedback
- Network coding
- Capacity of fading channels
- Broadcasting correlated sources
- Multi-path channels
- Interference networks
- Optical channels
- Topics in algebraic coding and probabilistic decoding

Digital Signal Processing

Current topics:

- Fundamentals and applications of graphical models (factor graphs)
- Model-based detection & estimation
- Digital calibration of analog circuits

Analog and Hybrid Signal Processing

Current topics:

- Digital-to-analog conversion and analog-to-digital conversion
- Joint synchronization and decoding

3.2 Current Research Topics

Prof. Amos Lapidoth (Information Theory)

The Free-Space Optical Intensity Channel at Low SNR

Free-space optical intensity channels are used to model infrared communication in an environment with strong ambient light. Hence of particular interest is the capacity at low SNR. We derive the asymptotic growth of the channel capacity at low SNR under average and/or peak power constraints.

On Multipath Fading Channels at High SNR

We study a discrete-time, non-coherent, multipath fading channel where the number of paths is finite. The focus is on capacity at high signal-to-noise ratios (SNR). In particular, we investigate the capacity pre-loglog, defined as the limiting ratio of capacity to $\log \log$ SNR as SNR tends to infinity.

Multipath Channels of Unbounded Capacity

We investigate the capacity of discrete-time, non-coherent, multipath fading channels. We study conditions under which channel capacity is unbounded in the allowed transmit power.

The Poisson Channel at Low Input Powers

We study the asymptotic capacity at low input powers of an average-power limited or an average-and-peak-power limited discrete-time Poisson channel. We consider channels whose dark currents are proportional to the input powers as well as channels whose dark currents are constant.

Wyner's Interference Network with Side-Information at Transmitters and Receivers

We consider a linear interference network modeling the communication in wireless cellular systems. For this network we explore a duality regarding transmitter side-information (cognition of other transmitters' messages) and receiver side-information (observation of other receivers' signals).

The Poisson Channel with Side Information

We study the capacity of the peak-limited Poisson channel with spurious counts whose positions are given a-causally as side-information to the transmitter but not to the receiver.

Coding for a Noisy Feedback Link

We study communication in the presence of a *noisy* feedback link. We assume that the feedback is active, so the noise on the feedback link can be combatted using coding. We study specific coding schemes as well as fundamental limits that hold for all coding schemes.

The Multiple Access Channel with Causal State Information

We study a state-dependent two-to-one multiple access channel (MAC), where the state sequence is available as side-information to the transmitters but not to the receiver. We consider two scenarios depending on whether the state sequence is known strictly causally or causally.

Prof. H.-A. Loeliger (Signal Processing)

Fundamentals and Applications of Graphical Models

Most of our research is somehow related to graphical models (factor graphs) and to message passing algorithms on such graphs. Topics include adaptation and learning, applied signal processing, modeling physical systems, and more.

Digital Calibration of Analog Circuits

We study the use of digital calibration techniques to reduce the area and the power consumption of analog circuits such as, e.g., analog-to-digital converters and digital-to-analog converters.

Joint Demodulation, Synchronization, and Decoding

We study signals, algorithms, and circuits for joint demodulation, synchronization, and decoding.

Polynomial Remainder Codes

We study algebraic codes that are derived from the Chinese Remainder Theorem.

Computational Information Theory

We use Monte-Carlo methods to compute information rates of source/channel models with a nontrivial Markov structure.

Modeling and Denoising Almost-Periodic Signals

We use time-varying Fourier series for modeling and denoising almost-periodic signals.

Robust Analog Circuits

We investigate large-scale analog circuits that can be built with small (high-mismatch) transistors.

3.3 Publications

- | | |
|--|---|
| Arnon S., Barry J.,
Karagiannidis G., Schober R.,
Uysal M. | “Advanced Optical Wireless Communication Systems”,
<i>Cambridge University Press</i> , ISBN Nr. 9780521197878. |
| Bross S.I., Lapidot A.,
Wigger M. | “Dirty-Paper Coding for the Gaussian Multiaccess Channel
Conferecing”, <i>IEEE Transactions on Information Theory</i> ,
Vol. 58, No. 3, pp 5640 - 5668 , September 2012. |
| Bunte Ch., Lapidot A. | “The Zero-Undetected-Error Capacity of Discrete
Memoryless Channels with Feedback”, <i>50th Allerton
Conference on Communication, Control, and Computing</i> ,
Monticello, Illinois, USA, October 1 – 5, 2012. |
| Devarakonda M., Loeliger H.-A. | “Joint synchronization and demodulation by forward
filtering”, <i>IEEE International Symposium on Information
Theory</i> , Cambridge, MA, USA, pp. 2406 – 2410, July 1 – 6, 2012. |

- Koch T., Lapidoth A. “One-bit quantizers for fading channels”, *IZS, Int. Zurich Seminar on Communications*, Zurich, Switzerland, February 29 – March 2, 2012.
- Lapidoth A., Wang L. “The State-Dependent Semideterministic Broadcast Channel”, *IEEE International Symposium on Information Theory*, Cambridge, MA, USA, July 1 – 6, 2012.
- Lapidoth A., Bracher A., Steinberg Y. “On Feedback, Cribbing and Causal State-Information on the Multiple Access Channel,” *ITW, Information Theory Workshop*, Lausanne, Switzerland, September 2 – 7, 2012.
- Lapidoth A. “Some problems are easier with feedback”, *LCCC, Workshop in Information and Control in Networks*, Lund, Sweden, October 17 – 19, 2012.
- Lapidoth A. “A Bit of Output Quantization and of Convexity”, *46th Conference On Information Sciences and Systems*, Princeton, USA, March 20 – 23, 2012.
- Lapidoth A. “Two by Gel’fand and Pinsker”, *IEEE European School of Information Theory*, Antalya, Turkey, April 16 – 20, 2012.
- Lapidoth A. “An application of the Krein–Milman Theorem to Channel-Output Quantization”, *IEEE Wirelss Adanced Conference London*, UK, June 22 – 27, 2012.
- Lapidoth A., Bunte Ch. “A note on the Erasures-Only Capacity”, *27th Convention of Electrical and Electronics Engineering*, Eilat, Israel, November 14 – 17, 2012.
- Loeliger H.-A., Vontobel P.O. “A factor-graph representation of propabilities in quantum mechanics”, *IEEE International Symposium on Information Theory*, Cambridge, MA, USA, pp. 661 - 665, July 1 – 6, 2012.
- Marano S., Reller Ch. Loeliger H.A., Fäh D. “Seismic waves estimation and wave field decomposition: application to ambient vibrations”, *Geophysical Journal International*, vol. 191, no. 1, pp. 175 – 188, October 2012.
- Molkaraie M., Loeliger H.-A. “Extending Monte Carlo methods to factor graphs with negative and complex kernels”, *IEEE Information Theory Workshop*, Lausanne, Switzerland, pp. 367 – 371, September 3 – 7, 2012.
- Reller Ch., Devarakonda M. Loeliger H.-A. “Glue factors, likelihood computation, and filtering in state space-models, *50th Annual Allerton Conference on Communication, Control, and Computing*, Monticello, Illinois, USA, October 1 – 5, 2012.
- Sabato G., Molkaraie M. “Generalized belief propagation for the noiseless capacity and information rates of run-length limited constraints”, *IEEE Trans. Communications*, vol. 60, pp. 669 – 675, March 2012.

3.4 Completed PhD Theses

BOLLIGER Lukas

Digital Estimation of Continuous-Time Signals Using Factor Graphs

ETH-Diss. Nr. 20123

Referee: Prof. Hans-Andrea Loeliger

Co-examiner: Prof. Dr. A. Singer, University of Illinois, Urbana-Champaign, USA
Dr. Ch. Vogel, University of Technology, Graz, Austria

RELLER Christoph

State-Space Methods in Statistical Signal Processing: New Ideas and Applications

ETH Diss. Nr. 20584

Referee: Prof. Hans-Andrea Loeliger

Co-examiner: Prof. Justin Dauwels, Nanyang Technological University,
Singapore

BIVERONI Jonas

On A/D Converters with Low-Precision Analog Circuits and Digital Post-Correction

ETH-Diss. Nr. 20629

Referee: Prof. Hans-Andrea Loeliger

Co-examiner: Prof. Boris Murmann, Stanford University, USA

4. Trips and Talks

4.1 Participation in Conferences and Meetings

Lapidoth Amos	Ben Gurion University of the Negev, Israel, Seminar, January 1 – 6.
Lapidoth Amos	IZS International Zurich Seminar on Communications, Zurich, February 29 – March 2.
Lapidoth Amos	CISS Conference on Information Sciences and Systems, Princeton Mass., USA, March 21 – 23.
Lapidoth Amos	IEEE European School of Information Theory, Antalya, Turkey, April 16 – 20.
Lapidoth Amos	IEEE Wireless Advanced Conference, London, UK, June 22 – 27.
Lapidoth Amos	IEEE International Symposium on Information Theory, Cambridge, MA, USA, July 1 – 6.
Lapidoth Amos	ITW Information Theory Workshop, Lausanne, September 2 – 7.
Lapidoth Amos	Workshop in Lund, Schweden, October 17 – 19.
Lapidoth Amos	IEEE 27 th Convention of Electrical and Electronics Engineering, Eilat, Israel, November 14 – 17.
Bunte Christoph	50 th Annual Allerton Conference on Communication, Control, and Computing, Monticello, IL, USA, October 1 – 5.
Loeliger H.A.	ITA Information and Applications Workshop, San Diego, USA February 5 – 10.
Loeliger H.A.	Pasadena, CA, TPC Meeting for ISIT 2012, April 13 – 15.
Loeliger H.A.	IEEE International Symposium on Information Theory, Cambridge, MA, USA, July 1 – 6.
Loeliger H.A.	ITW Information Theory Workshop, Lausanne, September 2 – 7.
Loeliger H.A.	50 th Annual Allerton Conference on Communication, Control, and Computing, Monticello, IL, USA, October 1 – 5.
Reller Christoph	6 th IEEE Workshop on Advanced Information Processing, for Wireless Communication Systems, Copenhagen, Denmark May 31 – June 1.
Yu Jiun-Hung	Conference “Trends in Coding Theory”, Centro Stefano Francini on Monte Verità, Ascona, October 28 – November 2.

4.2 Presentations by Institute Members Not Listed under 3.3

Loeliger H.A. “A factor-graph representation of probabilities in quantum mechanics”, 2012 Information Theory & Application Workshop (ITA), San Diego, CA, Feb. 5-10.

4.3 Invited Lectures and Seminars

11.01.2012	Prof. Andrew Singer , University of Illinois, Urbana-Champaign, “Communication-relevant metrics for A/D converters in communication systems”
09.05.2012	Tsachy Weissmann , Stanford University “Directed Information Estimation”
14.05.2012	Dr. Ligong Wang , MIT “The Poisson Channel in the High-Photon-Efficiency Regime”
11.07.2012	Dr. Tobias Koch , Universidad Carlos III de Madrid , Spain “The Capacity Loss of Dense Constellations”
17.07.2012	Prof. Justin Dauwels , Nanyang Techn. University, Singapore “Copula Graphical Models with Hidden Variables”
19.07.2012	Prof. Justin Dauwels , Nanyang Techn. University, Singapore “Modeling Extreme Events with Copula Graphical Models”
20.-23.8.2012	Prof. Igal Sason , Technion, Haifa, Israel “Mini Corse: “Concentrate”
11.09.2012	Prof. Boris Murman , Stanford University “Energy Limits in A/D Converters”
27.09.2012	Nikolai Nefedov “Community detection in complex networks: coupled dynamical systems approach
14.12.2012	Ashish Kishti “Delay-Sensitive and Trustworthy Wireless Communications”

5. Service Activities

5.1 Conference Organization

5.2 Other Service Activities and Society Memberships

Prof. Lapidoth

Fellow of the IEEE

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

Research Affiliate in the Research Laboratory of Electronics
RLE) at the Massachusetts Institute of Technology (MIT)

Member of the Center for Communication and Information
Technologies (CCIT), Technion, Haifa, Israel

Prof. Loeliger

Studiendelegierter D-ITET, ETH Zurich

Co-Chair, TPC of ISIT 2012

Member, TPC of IZS 2012

Member, TPC of Turbo Coding Symposium 2012, Göteborg

Member, TPC of ITW 2012, EPFL

Chair, IEEE Switzerland Chapter on Digital Communications

Member, Board of Governors, IEEE Information Theory Society