SampTA 2019
13th International conference on Sampling Theory and Applications
université de BORDEAUX
July 8-12

Friday July 12, 8.30-12.05 am

Wegener	8.30-9.30	*Robust and efficient identification of neural networks* Massimo Fornasier Chair: Bubacarr Bah
Wegener	9.30-10	*Coffee Break*

Quantization (invited session)
Chair: Sjoerd Dirksen & Rayan Saab

Wegener	10.00-10.25	*Robust One-bit Compressed Sensing With Manifold Data* Mark Iwen, Sjoerd Dirksen, Johannes Maly & Sara Krause-Solberg
Wegener	10.25-10.50	*One-Bit Sensing of Low-Rank and Bisparse Matrices* Simon Foucart & Laurent Jacques
Wegener	10.50-11.15	*Robust 1-Bit Compressed Sensing via Hinge Loss Minimization* Alexander Stollenwerk & Martin Genzel
Wegener	11.15-11.40	*High-performance quantization for spectral super-resolution* Sinan Gunturk & Weilin Li
Wegener	11.40-12.05	*On one-stage recovery for $\Sigma\Delta$-quantized compressed sensing* Ozgur Yilmaz & Arman Ahmadieh

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Wegener	8.30-9.30	*Title to be announced* Massimo Fornasier Chair: Bubacarr Bah
Wegener	9.30-10	*Coffee Break*
		Fourier analysis Chair: Jeffrey Hogan
Edison	10.00-10.25	*Riesz bases of exponentials for partitions of intervals* David Walnut, *Goetz E. Pfander* & Shauna Revay
Edison	10.25-10.50	*Computability of the Fourier Transform and ZFC* Holger Boche & Ullrich J. Mönich
Edison	10.50-11.15	*Rearranged Fourier Series and Generalizations to Non-Commutative Groups* Armenak Petrosyan, Keaton Hamm & Benjamin Hayes
Edison	11.15-11.40	*Deterministic guarantees for L^1-reconstruction: A large sieve approach with geometric flexibility* Michael Speckbacher & Luís Daniel Abreu
Edison	11.40-12.05	*A Clifford Construction of Multidimensional Prolate Spheroïdal Wave Functions* Hamed Baghal Ghaffari, Jeffrey Hogan & Joseph Lakey

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Robust and efficient identification of neural networks

Massimo Fornasier (Technical University, Munich, Germany)

Abstract: Identifying a neural network is an NP-hard problem in general. In this talk we address conditions of exact identification of one and two hidden layer totally connected feed forward neural networks by means of a number of samples, which scales polynomially with the dimension of the input and network size. The exact identification is obtained by computing second order approximate strong or weak differentials of the network and their unique and stable decomposition into nonorthogonal rank-1 terms. The procedure combines several novel matrix optimization algorithms over the space of second order differentials. As a byproduct we introduce a new whitening procedure for matrices, which allows the stable decomposition of symmetric matrices into nonorthogonal rank-1 decompositions, by reducing the problem to the standard orthonormal decomposition case. We show that this algorithm practically achieve information theoretical recovery bounds. We illustrate the results by several numerical experiments.

Joint work with Ingrid Daubechies, Timo Klock, Michael Rauchensteiner, and Jan Vybíral.

Quantization (invited session)

Chair: Sjoerd Dirksen & Rayan Saab

10.00-10.25: Robust One-bit Compressed Sensing With Manifold Data

Mark Iwen,*Sjoerd Dirksen*, Johannes Maly & Sara Krause-Solberg

Abstract: We study one-bit compressed sensing for signals on a low-dimensional manifold. We introduce two computationally efficient reconstruction algorithms that only require access to a geometric multi-resolution analysis approximation of the manifold. We derive rigorous reconstruction guarantees for these methods in the scenario that the measurements are subgaussian and show that they are robust with respect to both pre- and post-quantization noise. Our results substantially improve upon earlier work in this direction.

10.25-10.50: One-Bit Sensing of Low-Rank and Bisparse Matrices

Simon Foucart & Laurent Jacques

Abstract: This note studies the worst-case recovery error of low- rank and bisparse matrices as a function of the number of one-bit measurements used to acquire them. First, by way of the concept of consistency width, precise estimates are given on how fast the recovery error can in theory decay. Next, an idealized recovery method is proved to reach the fourth-root of the optimal decay rate for Gaussian sensing schemes. This idealized method being impractical, an implementable recovery algorithm is finally proposed in the context of factorized Gaussian sensing schemes. It is shown to provide a recovery error decaying as the sixth-root of the optimal rate.

Quantization (invited session)

Chair: Sjoerd Dirksen & Rayan Saab

10.50-11.15: Robust 1-Bit Compressed Sensing via Hinge Loss Minimization

Alexander Stollenwerk & Martin Genzel

Abstract: We study the problem of estimating a structured high-dimensional signal $x_0 \in \mathbb{R}^n$ from noisy 1-bit Gaussian measurements. Our recovery approach is based on a simple convex program which uses the hinge loss function as data fidelity term. While such a risk minimization strategy is typically applied in classification tasks, its capacity to estimate a specific signal vector is largely unexplored. In contrast to other popular loss functions considered in signal estimation, which are at least locally strongly convex, the hinge loss is just piecewise linear, so that its "curvature energy" is concentrated in a single point. It is therefore somewhat unexpected that we can still prove very similar types of recovery guarantees for the hinge loss estimator, even in the presence of strong noise. More specifically, our error bounds show that stable and robust reconstruction of x_0 can be achieved with the optimal oversampling rate $O(m^{-1/2})$ in terms of the number of measurements m. Moreover, we permit a wide class of structural assumptions on the ground truth signal, in the sense that x_0 can belong to an arbitrary bounded convex set $K \subset \mathbb{R}^n$. For the proofs of our main results we invoke an adapted version of Mendelson's small ball method that allows us to establish a quadratic lower bound on the error of the first order Taylor approximation of the empirical hinge loss function.

11.15-11.40: High-performance quantization for spectral super-resolution

Sinan Gunturk & Weilin Li

Abstract: We show that the method of distributed noise-shaping beta-quantization offers superior performance for the problem of spectral super-resolution with quantization whenever there is redundancy in the number of measurements. More precisely, if the (integer) oversampling ratio λ is such that $\lfloor M/\lambda \rfloor - 1 \geq 4/\Delta$, where M denotes the number of Fourier measurements and Δ is the minimum separation distance associated with the atomic measure to be resolved, then for any number $K \geq 2$ of quantization levels available for the real and imaginary parts of the measurements, our quantization method guarantees reconstruction accuracy of order $O(\lambda K^{-\lambda/2})$, up to constants which are independent of K and λ. In contrast, memoryless scalar quantization offers a guarantee of order $O(K^{-1})$ only.

Quantization (invited session)

Chair: Sjoerd Dirksen & Rayan Saab

11.40-12:05: On one-stage recovery for $\Sigma\Delta$-quantized compressed sensing

Ozgur Yilmaz & Arman Ahmadieh

Abstract: Compressed sensing is a signal acquisition paradigm that can be used to simultaneously acquire and reduce dimension of signals in high dimension that admit sparse representations with respect to an appropriate basis or frame. When such a signal is acquired according to the principles of compressed sensing, the resulting measurements still take on values in the continuum. In today's "digital" world, a subsequent quantization step, where these measurement values are replaced with elements from a finite set is crucial. After briefly reviewing the literature on quantization for compressed sensing, we will focus on one of the approaches that yield efficient quantizers for compressed sensing: $\Sigma\Delta$ quantization, followed by a one-stage reconstruction method that is based on solving a tractable convex optimization problem. This approach was developed by Wang, Saab, and Yilmaz with theoretical error guarantees in the case of sub-Gaussian matrices. We propose two alternative approaches that extend the results of that paper to a wider class of measurement matrices. These include (certain unitary transforms of) partial bounded orthonormal systems and deterministic constructions based on chirp sensing matrices.

Fourier analysis

Chair: Jeffrey Hogan

10.00-10.25: Riesz bases of exponentials for partitions of intervals

David Walnut, *Goetz E. Pfander* & Shauna Revay

Abstract: For a partition of $[0, 1]$ with nodes $0 = a_0 < a_1 < \cdots < a_{n-1} < a_n = 1$, we construct a partition of $\mathbb{Z}$, $\Lambda_1, \Lambda_2, \ldots, \Lambda_n$ such that $\mathcal{E}(\Lambda_j)$ is a Riesz basis for $L^2[a_{j-1}, a_j]$. Our construction also guarantees that $\mathcal{E}\left(\bigcup_{j=1}^{k} \Lambda_j\right)$ is a Riesz basis for $L^2[0, a_k]$, and $\mathcal{E}\left(\bigcup_{j=k+1}^{n} \Lambda_j\right)$ is a Riesz basis for $L^2[a_k, 1]$.

10.25-10.50: Computability of the Fourier Transform and ZFC

Holger Boche & *Ullrich J. Mönich*

Abstract: In this paper we study the Fourier transform and the possibility to determine the binary expansion of the values of the Fourier transform in the Zermelo–Fraenkel set theory with the axiom of choice included (ZFC). We construct a computable absolutely integrable bandlimited function with continuous Fourier transform such that ZFC (if arithmetically sound) cannot determine a single binary digit of the binary expansion of the Fourier transform at zero. This result implies that ZFC cannot determine for every precision goal a rational number that approximates the Fourier transform at zero. Further, we discuss connections to Turing computability.

Fourier analysis

Chair: Jeffrey Hogan

10.50-11.15: Rearranged Fourier Series and Generalizations to Non-Commutative Groups

Armenak Petrosyan, Keaton Hamm & Benjamin Hayes

Abstract: It is well-known that the Fourier series of continuous functions on the torus are not always uniformly convergent. However, P. L. Ulyanov proposed a problem: *can we permute the Fourier series of each individual continuous function in such a way as to guarantee uniform convergence of the rearranged Fourier series?* This problem remains open, but nonetheless a rather strong partial result was proved by S. G. Revesz which states that for every continuous function there exists a subsequence of rearranged partial Fourier sums converging to the function uniformly. We give several new equivalences to Ulyanov's problem in terms of the convergence of the rearranged Fourier series in the strong and weak operator topologies on the space of bounded operators on $L^2(\mathbb{T})$. This new approach gives rise to several new problems related to rearrangement of Fourier series. We also consider Ulyanov's problem and Revesz's theorem for reduced C^*-algebras on discrete countable groups.

11.15-11.40: Deterministic guarantees for L^1-reconstruction: A large sieve approach with geometric flexibility

Michael Speckbacher & Luís Daniel Abreu

Abstract: We present estimates of the p-concentration ratio for various function spaces on different geometries including the line, the sphere, the plane, and the hyperbolic disc, using large sieve methods. Thereby, we focus on L^1-estimates which can be used to guarantee the reconstruction from corrupted or partial information.

Fourier analysis

Chair: Jeffrey Hogan

11.40-12.05: A Clifford Construction of Multidimensional Prolate Spheroïdal Wave Functions

Hamed Baghal Ghaffari, Jeffrey Hogan & Joseph Lakey

Abstract: We investigate the construction of multidimensional prolate spheroidal wave functions using techniques from Clifford analysis. The prolates defined to be eigenfunctions of a certain differential operator and we propose a method for computing these eigenfunctions through expansions in Clifford-Gegenbauer polynomials. It is shown that the differential operator commutes with a time-frequency limiting operator defined relative to balls in n-dimensional Euclidean space.