Biophysical Journal

Vol. 111, no. 7

Single-Molecule Analysis beyond Dwell Times: Demonstration and Assessment in and out of Equilibrium
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We present a simple and robust technique for extracting kinetic rate models and thermodynamic quantities from single-molecule time traces. Single-molecule analysis of complex kinetic sequences (SMACKS) is a maximum-likelihood approach that resolves all statistically relevant rates and also their uncertainties. This is achieved by optimizing one global kinetic model based on the complete data set while allowing for experimental variations between individual trajectories. In contrast to dwell-time analysis, which is the current standard method, SMACKS includes every experimental data point, not only dwell times. As a result, it works as well for long trajectories as for an equivalent set of short ones. In addition, the previous systematic overestimation of fast over slow rates is solved. We demonstrate the power of SMACKS on the kinetics of the multidomain protein Hsp90 measured by single-molecule Förster resonance energy transfer. Experiments in and out of equilibrium are analyzed and compared to simulations, shedding new light on the role of Hsp90’s ATPase function. SMACKS resolves accurate rate models even if states cause indistinguishable signals. Thereby, it pushes the boundaries of single-molecule kinetics beyond those of current methods.

Vol. 111, no. 8,9
Nothing of interest

Proceedings of the National Academy of Sciences, USA

Vol. 117, no. 40,41
Nothing of interest.

Vol. 117, no. 42
Dissection of molecular assembly dynamics by tracking orientation and position of single molecules in live cells

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Regulation of order, such as orientation and conformation, drives the function of most molecular assemblies in living cells but remains difficult to measure accurately through space and time. We built an instantaneous fluorescence polarization microscope, which simultaneously images
position and orientation of fluorophores in living cells with single-molecule sensitivity and a time resolution of 100 ms. We developed image acquisition and analysis methods to track single particles that interact with higher-order assemblies of molecules. We tracked the fluctuations in position and orientation of molecules from the level of an ensemble of fluorophores down to single fluorophores. We tested our system in vitro using fluorescently labeled DNA and F-actin, in which the ensemble orientation of polarized fluorescence is known. We then tracked the orientation of sparsely labeled F-actin network at the leading edge of migrating human keratinocytes, revealing the anisotropic distribution of actin filaments relative to the local retrograde flow of the F-actin network. Additionally, we analyzed the position and orientation of septin-GFP molecules incorporated in septin bundles in growing hyphae of a filamentous fungus. Our data indicate that septin-GFP molecules undergo positional fluctuations within ~350 nm of the binding site and angular fluctuations within ~30° of the central orientation of the bundle. By reporting position and orientation of molecules while they form dynamic higher-order structures, our approach can provide insights into how micrometer-scale ordered assemblies emerge from nanoscale molecules in living cells.

Vol. 117, no. 43, 44, 45
Nothing of interest.

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Review of Scientific Instruments

vol. 87, no 9, 10
Nothing of interest.

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Physical Review E

Vol. 94, no. 3,4,5
Nothing of interest.

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Oklahoma State University and University of Nevada, Reno.

In this paper, we propose a compressive and collaborative sensing (CCS) algorithm for distributed robotic networks to build scalar field map. A collaborative control law is utilized to steer the robots to move on the field while avoiding collision with each other and with obstacles. At each time instant, the robots collect, add measurements within their sensing range and exchange data with their neighbors to form compressive sensing (CS) measurements at each robot. After a certain times of moving and sampling, each robot can achieve that number of CS measurements to be able to reconstruct all sensory readings from the positions that the group of robots visited to build a scalar map. We further analyze and formulate the total communication power consumption associated with the number of robots, sensor communication range and provide suggestions for more energy saving.
Journal Updates:

November 2016

Automatica

Greedy controllability of finite dimensional linear systems

*Volume 74, December 2016, Pages 327–340*

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**Abstract**
We analyse the problem of controllability for parameter dependent linear finite-dimensional systems. The goal is to identify the most distinguished realisations of those parameters so to better describe or approximate the whole range of controls. We adapt recent results on greedy and weak greedy algorithms for parameter dependent PDEs or, more generally, abstract equations in Banach spaces. Our results lead to optimal approximation procedures that, in particular, perform better than simply sampling the parameter-space to compute the controls for each of the parameter values. We apply these results for the approximate control of finite-difference approximations of the heat and the wave equation. The numerical experiments confirm the efficiency of the methods and show that the number of weak-greedy samplings that are required is particularly low when dealing with heat-like equations, because of the intrinsic dissipativity that the model introduces for high frequencies.

**(Brief paper)** LQ-based event-triggered controller co-design for saturated linear systems

*Volume 74, December 2016, Pages 47–54*

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**Abstract**
This paper deals with the simultaneous design of a state feedback law and an event-triggering condition ensuring local exponential stability and LQ performance in the presence of plant input saturation and of a communication channel between the controller output and the saturated plant input. To this aim, we adopt Lyapunov-based techniques in a hybrid framework. The design of the event-triggered control is based on two conditions: one to solve the event-triggered control co-design for LQ stabilization; the second one to adjust the co-design among all possible solutions of the first condition thanks to a tunable parameter. The proposed
Lyapunov formulation yields an event-triggered algorithm to update the saturated plant input based on conditions involving the closed-loop state, while an estimate of the domain of attraction is provided. Furthermore, a trade-off is highlighted relating the optimality level, the size of the estimate of the basin of attraction and the reduction of the amount of transmissions.

(Brief paper) Reachability and observability reduction for linear switched systems with constrained switching

*Volume 74, December 2016, Pages 162–170*

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**Abstract**

We present an algorithm for reducing the number of continuous states of a discrete time linear switched system, such that the reduced system has the same input–output behavior as the original system for a subset of switching sequences. The procedure can be interpreted as reachability and observability reduction for a linear switched system with constrained switching. The proposed method is expected to be useful for abstraction based control synthesis methods for hybrid systems.
Controllability of the multi-agent system modeled by the threshold graph with one repeated degree

Volume 97, November 2016, Pages 149–156

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Abstract
The controllability issue of multi-agent systems modeled by a special class of graphs is studied. Suppose the modeling graph is simple, connected and driven by only one controller. The author shows that the system is controllable if the graph has exactly two vertices with the same degree and either one of these two vertices is selected to receive the control input. This result is extended to the case of the threshold graph that has only one repeated degree. Specifically, it is shown that if the threshold graph has only one repeated degree and its multiplicity is m, then m−1 is the minimum number of the controllers required to make the system controllable. In addition, the necessary and sufficient condition that characterizes the binary control vectors to ensure the controllability of the system is derived.

A uniform invariance principle for periodic systems with applications to synchronization

Volume 97, November 2016, Pages 48–54

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Abstract
In this paper, we propose an extension of the invariance principle, which is uniform with respect to parameter uncertainties, for the class of periodic ordinary differential equations. This extension allows the derivative of the auxiliary function V, commonly called a Lyapunov function, to be positive in some bounded sets. This important feature has the potential to simplify the problem of exhibiting a function of Lyapunov-type and allows the application of the principle in systems that cannot be treated with the conventional principle, either due to the nonexistence of a Lyapunov-type function or due to the difficulty in exhibiting it. The extension of the invariance principle is useful to obtain estimates of attractors and regions of attraction that are uniform with respect to parameters. The study of synchronization of periodic coupled systems illustrates an application of the principle.
Model matching with strong stability in switched linear systems

Volume 97, November 2016, Pages 98–107

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Abstract

This work deals with model matching by output dynamic feedback in switched linear systems. The plant and the model are assumed to be subject to different switching signals. A necessary and sufficient condition for achieving model matching with asymptotic stability of both the closed-loop compensated system and the compensator, for a sufficiently large dwell time, is proven. Such condition is obtained by specializing the structural condition with a suitable redefinition of the robust controlled invariant subspace involved, capable of capturing not only the structural aspect of the problem but also the stability aspects. The effect of the combined action of nonzero initial states and nonzero inputs is dealt with. The solution to a more demanding problem formulation, where the dwell time is assumed to be fixed and given is also discussed.
IEEE Transactions on Robotics

Global Planning for Multi-Robot Communication Networks in Complex Environments

Volume: 32, Issue: 5, Page(s): 1045 - 1061

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Abstract:
In this paper, we consider networks of mobile robots responsible for servicing a collection of tasks in complex environments, while ensuring end-to-end connectivity with a fixed infrastructure of access points. Tasks are associated with specific locations in the environment, are announced sequentially, and are not assigned a priori to any robots. Information generated at the tasks is propagated to the access points via a multihop communication network. We propose a distributed, hybrid control scheme that dynamically grows tree networks, rooted at the access points, with branches that connect robots that service individual tasks to the main network structure. To achieve this goal, the robots switch between different roles related to their functionality in the network. The switching process is tightly integrated with distributed optimization of the communication variables and motion planning in complex environments, giving rise to the proposed distributed hybrid system. Our proposed scheme results in an efficient use of the available robots and also allows for global planning by construction, a task that is particularly challenging in complex environments.

Moving Path Following for Unmanned Aerial Vehicles with Applications to Single and Multiple Target Tracking Problems

Volume: 32, Issue: 5, Page(s): 1062 - 1078

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Abstract:
This paper introduces the moving path following (MPF) problem, in which a vehicle is required to converge to and follow a desired geometric moving path, without a specific temporal specification, thus generalizing the classical path following that only applies to stationary paths. Possible tasks that can be formulated as an MPF problem include tracking terrain/air vehicles and gas clouds monitoring, where the velocity of the target vehicle or cloud specifies the motion of the desired path. We derive an error space for MPF for the general case of time-varying paths in a two-dimensional space and subsequently an application is described for the problem of tracking single and multiple targets on the ground using an unmanned aerial vehicle (UAV) flying at constant altitude. To this end, a Lyapunov-based MPF control law and a path-generation algorithm are proposed together with convergence and performance metric results. Real-world flight tests results that took place in Ota Air Base, Portugal, with the ANTEX-X02 UAV demonstrate the effectiveness of the proposed method.
Correlated Orienteering Problem and its Application to Persistent Monitoring Tasks

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Abstract:
We propose the correlated orienteering problem (COP) as a novel nonlinear extension to the classic orienteering problem (OP). With the introduction of COP, it becomes possible to model the planning of informative tours for the persistent monitoring of a spatiotemporal field with time-invariant spatial correlations using autonomous mobile robots, in which the robots are range- or time-constrained. Our focus in this paper is QCOP, a quadratic COP instantiation that looks at correlations between neighboring nodes in a node network. The main feature of QCOP is a quadratic utility function capturing the said spatial correlation. We solve QCOP using mixed integer quadratic programming, with the resulting anytime algorithm capable of planning multiple disjoint tours that maximize the quadratic utility. In particular, our algorithm can quickly plan a near-optimal tour over a network with up to 150 nodes. Beside performing extensive simulation studies to verify the algorithm's correctness and characterize its performance, we also successfully applied QCOP to two realistic persistent monitoring tasks: 1) estimation over a synthetic spatiotemporal field and 2) estimating the temperature distribution in the state of Massachusetts in the United States.

Optimal Multirobot Path Planning on Graphs: Complete Algorithms and Effective Heuristics

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Department of Computer Science, University of Illinois at Urbana-Champaign, Champaign, IL, USA

Abstract:
We study optimal multirobot path planning on graphs (MPP) over four minimization objectives: the makespan (last arrival time), the maximum (single-robot traveled) distance, the total arrival time, and the total distance. Having established previously that these objectives are distinct and NP-hard to optimize, in this paper, we focus on efficient algorithmic solutions for solving these optimal MPP problems. Toward this goal, we first establish a one-to-one solution mapping between MPP and a special type of multiflow network. Based on this equivalence and integer linear programming (ILP), we design novel and complete algorithms for optimizing over each of the four objectives. In particular, our exact algorithm for computing optimal makespan solutions is a first that is capable of solving extremely challenging problems with robot-vertex ratios as high as 100%. Then, we further improve the computational performance of these exact algorithms through the introduction of principled heuristics, at the expense of slight optimality loss. The combination of ILP model based algorithms and the heuristics proves to be highly effective, allowing the computation of 1.x-optimal solutions for problems containing hundreds of robots, densely populated in the environment, often in just seconds.
**Brief Review of Dissipativity Theory**

*Networks of Dissipative Systems*

*Part of the series Springer Briefs in Electrical and Computer Engineering pp 1-11*

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Department of Mechanical Engineering, University of California, Berkeley

**Abstract**

This chapter reviews concepts from dissipativity theory that are foundational for the subsequent chapters. It first gives the general definition and, next, discusses special types of dissipativity that describe finite $L_2$ gain, passivity, and output strict passivity properties, followed by a graphical interpretation of each type for memoryless systems. The next topic is differential characterization of dissipativity and its specialization to linear systems. This is followed by numerical techniques for certifying dissipativity via semidefinite programming. The final section illustrates the use of dissipativity for reachability and Lyapunov stability analysis.
Analytical computation of the energy-efficient optimal planning in rest-to-rest motion of constant inertia systems

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Abstract:
Among the techniques to improve energy efficiency of mechatronic systems, the synthesis of optimized motion profiles has been proved to be an effective and almost costless method. In order to boost the use of this approach, this paper proposes an analytical method for improving energy efficiency in rest-to-rest motion through optimal planning, by selecting both the optimal motion law and the optimal motion time (duration). The proposed technique is suitable for constant inertia systems. As a matter of fact, this kind of mechatronic systems covers a wide range of applications in production, packaging or logistic plants.

The method practical application is straightforward, since it just relies on the knowledge of the task specifications and of some system parameters to compute the optimal motion time for each selected trajectory and to compare analytically different motion profiles. The limitations due the servo-actuator (torque, speed, bandwidth), to machine throughput requirements, as well as the smoothness specifications (acceleration and jerk limitations, degree of continuity) are explicitly accounted for through bounds, to ensure the feasibility of the motion profiles developed.

Since the proposed method proposes an analytical algebraic equation, it does not require either time-consuming simulations and trial-and-error evaluations, or numerical optimizations. Hence, it is well suited for industrial mechatronic applications.
Review of fractional PID controller

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Abstract:
Fractional calculus has been studied for over three centuries, and it has multifarious applications in science and engineering. This review investigates its progress since the first reported use of control systems, covering the fractional PID proposed by Podlubny in 1994, and is presenting a state-of-the-art fractional PID controller, incorporating the latest contributions in this field. It highlights developments in the field of fractional PID controllers, including their design and tuning, as well as explores their various versions. Software tools associated to the design of fractional PID controllers are also discussed.

Resource-efficient ILC for LTI/LTV systems through LQ tracking and stable inversion: Enabling large feedforward tasks on a position-dependent printer

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Abstract:
Iterative learning control (ILC) enables high performance for systems that execute repeating tasks. Norm- optimal ILC based on lifted system representations provides an analytic expression for the optimal feed- forward signal. However, for large tasks the computational load increases rapidly for increasing task lengths, compared to the low computational load associated with so-called frequency domain ILC designs. The aim of this paper is to solve norm-optimal ILC through a Riccati-based approach for a general performance criterion. The approach leads to exactly the same solution as found through lifted ILC, but at a much smaller
computational load (O(N) vs O(N^3)) for both linear time-invariant (LTI) and linear time-varying (LTV) systems. Interestingly, the approach involves solving a two-point boundary value problem (TPBVP). This is shown to have close connections to stable inversion techniques, which are central in typical frequency domain ILC designs. The proposed approach is implemented on an industrial flatbed printer with large tasks which cannot be implemented using traditional lifted ILC solutions. The proposed methodologies and results are applicable to both ILC and rational feedforward techniques by applying them to suitable closed-loop or open-loop system representations. In addition, they are applied to a position-dependent system, revealing necessity of addressing position-dependent dynamics and confirming the potential of LTV approaches in this situation.

+One:


Reconstruction of missing data using compressed sensing techniques with adaptive dictionary

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Abstract:
Missing data is a commonly encountered and challenging issue in data-driven process analysis. Several methods that attempt to estimate missing observations for the purpose of control, identification, etc. have been developed over the decades. However, existing methods tend to produce erroneous estimates when the percentage of missing data is high and mostly do not exploit the benefit of parsimonious or sparse signal representations. Recently developed compressed sensing (CS) techniques are naturally suited to handle the problem of missing data recovery since they provide powerful signal recovery methods that take advantage of sparse representations of signals in a set of functions, known as the overcomplete dictionary. A majority of these signal recovery algorithms assume that the dictionary is known beforehand. This paper presents a method to estimate missing observations using CS ideas, but with an adaptive learning of the overcomplete dictionary from data. The method is particularly devised for signals that have a block-diagonal sparse representation, an assumption that is not too restrictive. An iterative optimization method, consisting of an iterative CS problem on
block-segmented data, for discovering this sparsifying dictionary is presented. Further, we present theoretical and practical guidelines for the segmentation size. It is shown that the error at each iteration is bounded for the exact, i.e., zero model mismatch and noise-free, case. Demonstrations on five different systems illustrate the efficacy of the proposed method with respect to recovery of missing data and convergence properties. Finally, the method is observed to require fewer observations than a fixed dictionary for a given reconstruction accuracy.
**L2–Gain Analysis for a Class of Hybrid Systems with Applications to Reset and Event-Triggered Control: A Lifting Approach**

W. P. M. H. Heemels (Technische Universiteit Eindhoven), G. E. Dullerud (University of Illinois, Urbana-Champaign), and A. R. Teel (UCSB),

The authors study a class of continuous-time hybrid systems with linear dynamics, periodic time-triggered jumps, and arbitrary jump maps, for which they propose novel stability and L2-gain analysis methods. Specifically, it is shown that properties such as stability and contractivity map to similar properties of an appropriate discrete-time nonlinear system. This leads to significantly less conservative conditions than existing results. The proposed framework applies to applications in, amongst others, periodic event-triggered control, reset control, networked control systems, and sampled-data saturated control.

**Stability of an Euler-Bernoulli Beam with a Nonlinear Dynamic Feedback System**

D. Stuerzer (TU Wien, Vienna), A. Kugi, A. Arnold, and M. Miletic

This article considers stabilization of a lossless Euler-Bernoulli beam with a tip mass by nonlinear dynamic boundary feedback. This nonlinear dynamic boundary feedback may represent the dynamics of the actuators delivering the external torque and force. Asymptotic stability of classical solutions of the closed-loop system is shown. The proof utilizes semigroup theory and Lyapunov theory. Crucial in the analysis is showing precompactness of the trajectories.

**Stochastic Control with uncertain Parameters via Chance Constrained Control**

M. P. Vitus (Stanford), Z. Zhou (Stanford), and C. J. Tomlin (Berkeley)

This paper extends existing chance constrained methods to handle both uncertainty in the system state and in the constraint parameters. A novel hybrid method is proposed that uses both analytical functions and sampling to represent the uncertainty. It is shown that under certain conditions, the resulting optimization program is convex. To check the convexity, an efficient a priori, sufficient condition is developed. Furthermore, by using this hybrid representation, the method drastically reduces the computational complexity over previous methods thus making it useful in real-time stochastic control for the motivating applications.
**State Classification of Time-Nonhomogeneous Markov Chains and Average Reward Optimization of Multi-Chains**

XiRen Cao (Hong Kong Univ. of Science and Technology)

This paper focuses on nonhomogeneous Markov chains (TNHMC), in which the state spaces, transition probabilities, and reward functions at different times may be different. By using the notion of confluency, the author shows that the states of a TNHMC can be classified into branching states and a number of classes of confluent states. This result is then used to show that, under some mild conditions, necessary and sufficient conditions for optimal policies can be obtained for TNHMC’s consisting of multiple confluent classes.

+1 IEEE Transactions on Signal Processing: Vol. 65, Issue 1

**Optimized Spectrum Permutation for the Multidimensional Sparse FFT**

André Rauh, Gonzalo R. Arce (Both University of Delaware, Newark)

A multidimensional sparse fast Fourier transform algorithm is introduced via generalizations of key concepts used in the one-dimensional (1-D) sparse Fourier transform algorithm. It is shown that permutation parameters are of key importance and should not be chosen randomly but instead can be optimized. A connection is made between the sparse Fourier transform algorithm and lattice theory, thus establishing a rigorous understanding of the effect of the permutations on the algorithm performance. Lattice theory is then used to optimize the set of parameters to achieve a more robust and better performing algorithm. Other algorithms using pseudorandom spectrum permutation can also benefit from the methods developed in this paper. The contributions address the case of the exact k-sparse Fourier transform but the underlying concepts can be applied to the general case of finding a k -sparse approximation of the Fourier transform of an arbitrary signal. Simulations illustrate the efficiency and accuracy of the proposed algorithm. The optimizations of the parameters and the improved performance are shown in simulations for the 2-D case where worst case and average case peak signal-to-noise ratio (PSNR) improves by several decibels.

**Perfect Recovery Conditions for Non-negative Sparse Modeling**

Yuki Itoh ; Marco F. Duarte ; Mario Parente (All U.Mass. Amherst)

Sparse modeling has been widely and successfully used in many applications, such as computer vision, machine learning, and pattern recognition. Accompanied with those applications, significant research has studied the theoretical limits and algorithm design for convex relaxations in sparse modeling. However, theoretical analyses on non-negative versions of sparse modeling are limited in the literature either to a noiseless setting or a scenario with a specific statistical noise model, such as Gaussian noise. This paper studies the performance of non-negative sparse modeling in a more general scenario where the observed signals have an unknown arbitrary distortion, especially focusing on non-negativity constrained and L1-penalized least squares, and gives an exact bound for which this problem can recover the correct signal elements. We pose two conditions to guarantee the correct signal recovery: minimum coefficient condition and nonlinearity versus subset coherence condition. The former defines the minimum weight for each of the correct atoms present in the signal and the latter defines the tolerable deviation from the
linear model relative to the positive subset coherence, a novel type of "coherence" metric. We provide rigorous performance guarantees based on these conditions and experimentally verify their precise predictive power in a hyperspectral data unmixing application.

**A Bayesian Approach for Online Recovery of Streaming Signals From Compressive Measurements**

Uditha Lakmal Wijewardhana ; Marian Codreanu (Both Univ. of Oulu, Oulu Finland)

We consider the progressive reconstruction of a streaming signal from compressive, streaming measurements. We develop a progressive reconstruction algorithm based on sliding window processing, where we reconstruct the streaming signal over small overlapping shifting intervals. Since the consecutive intervals share some common sparse signal vectors, the key idea of this work is to utilize the preliminary information from the preceding interval to improve the performance of the signal recovery algorithm. For this purpose, we propose a novel sparse Bayesian learning (SBL) algorithm, which is highly efficient for recovering streaming signals. One major advantage of SBL is that it provides a measure of uncertainty of the reconstructed signal rather than computing only a point estimate. The proposed SBL algorithm utilizes the previous estimates as well as the correlations among the nonzero coefficients to improve the performance of the algorithm. Since the effect of uncertainty of the reconstructed signal from the preceding interval is specifically taken into account in the recovery process of the current interval, the proposed algorithm is more robust to the error propagation compared to the l1 -norm minimization counterpart. Further, we propose a warm-start procedure and derive fast update formulae to reduce the computational cost of the SBL algorithm. In addition, we also discuss the properties of the signal and the underlying approximations which enable the progressive reconstruction of the streaming signal from compressive measurements.
Noisy Compressive Sampling Based on Block-Sparse Tensors: Performance Limits and Beamforming Techniques
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Abstract
Compressive sampling (CS) is an emerging research area for the acquisition of sparse signals at a rate lower than the Shannon sampling rate. Recently, CS has been extended to the challenging problem of multidimensional data acquisition. In this context, block-sparse core tensors have been introduced as the natural multidimensional extension of block-sparse vectors. The (M₁,..., Mₐ) block sparsity for a tensor assumes that a support sets, characterized by Mq indices corresponding to the nonzero entries, fully describe the sparsity pattern of the considered tensor. In the context of CS with Gaussian measurement matrices, the Cramer-Rao bound (CRB) on the estimation accuracy of a Bernoulli-distributed block-sparse core tensor is derived. This prior assumes that each entry of the core tensor has a given probability to be nonzero, leading to random supports of truncated Binomial-distributed cardinalities. Based on the limit form of the Poisson distribution, an approximated CRB expression is given for large dictionaries and a highly block-sparse core tensor. Using the property that the mode unfolding matrices of a block-sparse tensor follow the multiple-measurement vectors (MMV) model with a joint sparsity pattern, a fast and accurate estimation scheme, called Beamformed Mode based Sparse Estimator (BOSE), is proposed in the second part of this paper. The main contribution of the BOSE is to map the MMV model onto the single MV model, thanks to beamforming techniques. Finally, the proposed performance bounds and the BOSE are applied in the context of CS to 1) nonbandlimited multidimensional signals with separable sampling kernels and 2) for multipath channels in a multiple-input multiple-output wireless communication scheme.

Simultaneous Bayesian Sparse Approximation With Structured Sparse Models
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Abstract
Sparse approximation is key to many signal processing, image processing, and machine learning applications. If multiple signals maintain some degree of dependency, for example, the support sets are statistically related, then it will generally be advantageous to jointly estimate the sparse representation vectors from the measurement vectors as opposed to solving for each signal individually. In this paper, we propose simultaneous sparse Bayesian learning (SBL) for joint sparse approximation with two structured sparse models (SSMs), where one is row-sparse with embedded element-sparse and the other one is row-sparse plus element-sparse. While SBL has attracted much attention as a means to deal with a single sparse approximation problem, it is not obvious how to extend SBL to SSMs. By capitalizing on a dual-space view of existing convex methods for SMs, we showcase the precision component model and covariance component model for SSMs, where both models involve a common hyperparameter and an innovation hyperparameter that together control the prior variance for each coefficient. The statistical perspective of precision component versus covariance component models unfolds the intrinsic mechanism in SSMs, and also leads to our development of SBL-inspired cost functions for SSMs. Centralized algorithms that include 11 and 12 reweighting algorithms and consensus-based decentralized algorithms are developed for simultaneous sparse approximation with SSMs. In addition, theoretical analysis
is conducted to provide valuable insights into the proposed approach, which includes global minima analysis of the SBL-inspired nonconvex cost functions and convergence analysis of the proposed 11 reweighting algorithms for SSMs. Superior performance of the proposed algorithms is demonstrated by numerical experiments.

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**Sampling and Reconstruction in Arbitrary Measurement and Approximation Spaces Associated With Linear Canonical Transform**

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**Abstract**  
The linear canonical transform (LCT), which generalizes many classical transforms, has been shown to be a powerful tool for signal processing and optics. Sampling theory of the LCT for bandlimited signals has blossomed in recent years. However, in practice signals are never perfectly bandlimited, and in many cases measurement devices are nonideal. The objective of this paper is to develop a sampling theorem for the LCT from general measurements, which can provide a suitable and realistic model of sampling and approximation for real-world applications. We first describe a general class of approximation spaces for the LCT and provide a full characterization of their basis functions. Then, we propose a generalized sampling theorem for arbitrary measurement and approximation spaces associated with the LCT. Several properties of the proposed sampling theorem are also discussed. Furthermore, the approximation error is estimated. Finally, numerical results and several applications of the derived results are presented.

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**Image Inpainting Through Metric Labeling via Guided Patch Mixing**

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**Abstract**  
In this paper, we present a novel formulation of exemplar-based image inpainting as a metric labeling problem, and solve it through the simulated annealing algorithm. Due to their greedy nature, exemplar-based methods sometimes produce inpainted images, which are visually inconsistent. These methods are highly dependent upon the initialization. To solve these problems, we generate five images with a different initialization. A suitable mixture of these five images produces a good inpainted image. The cost function of the proposed metric labeling problem consists of three components, namely, neighbor cost, total variation cost, and structure cost. A linear combination among these components is used to maintain better visual consistency in the inpainted region having smooth transition from the bordering regions of the source image. We use a quality measure to this end. Our experiments on a wide variety of images demonstrate that the proposed technique produces better inpainting images as compared with some other state-of-the-art techniques.

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**Compressive Sampling-Based Image Coding for Resource-Deficient Visual Communication**

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**Abstract**  
In this paper, a new compressive sampling-based image coding scheme is developed to achieve competitive coding efficiency at lower encoder computational complexity, while supporting error resilience. This technique is particularly suitable for visual communication with resource-deficient devices. At the encoder, compact image representation is produced, which is a polyphase down-sampled version of the input image; but the conventional low-pass filter prior to down-sampling is replaced by a local random binary convolution kernel. The pixels of the resulting down-sampled pre-filtered image are local random measurements and placed in the original spatial
configuration. The advantages of the local random measurements are two folds: 1) preserve high-frequency image features that are otherwise discarded by low-pass filtering and 2) remain a conventional image and can therefore be coded by any standardized codec to remove the statistical redundancy of larger scales. Moreover, measurements generated by different kernels can be considered as the multiple descriptions of the original image and therefore the proposed scheme has the advantage of multiple description coding. At the decoder, a unified sparsity-based soft-decoding technique is developed to recover the original image from received measurements in a framework of compressive sensing. Experimental results demonstrate that the proposed scheme is competitive compared with existing methods, with a unique strength of recovering fine details and sharp edges at low bit-rates.

Double-Tip Artifact Removal From Atomic Force Microscopy Images
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Abstract
The atomic force microscopy (AFM) allows the measurement of interactions at interfaces with nanoscale resolution. Imperfections in the shape of the tip often lead to the presence of imaging artifacts, such as the blurring and repetition of objects within images. In general, these artifacts can only be avoided by discarding data and replacing the probe. Under certain circumstances (e.g., rare, high-value samples, or extensive chemical/physical tip modification), such an approach is not feasible. Here, we apply a novel deblurring technique, using a Bayesian framework, to yield a reliable estimation of the real surface topography without any prior knowledge of the tip geometry (blind reconstruction). A key contribution is to leverage the significant recently successful body of work in natural image deblurring to solve this problem. We focus specifically on the double-tip effect, where two asperities are present on the tip, each contributing to the image formation mechanism. Finally, we demonstrate that the proposed technique successfully removes the double-tip effect from high-resolution AFM images, which demonstrate this artifact while preserving feature resolution.