
2014 International workshop on Signal Processing, Optimization and Compressed Sensing

# SPOC 2014

# 秩 序 册

长沙，2014.12

承办单位：国防科学技术大学

# 会议主题与会务组织机构

**会议主题：** Signal Processing
Optimization
Compressed Sensing

**组织委员会（拼音顺序）：**

文再文　　北京大学
印卧涛　　加州大学洛杉矶分校
袁晓明　　香港浸会大学
朱炬波　　国防科学技术大学

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- Xiaoqun Zhang (张小群), Retinex by higher order total variation L^1 decomposition, 上海交通大学
- Rongjie Lai (赖荣杰), Non-rigid point cloud registration using robust sliced-Wasserstein distance via Laplace-Beltrami eigenmap，Rensselaer Polytechnic Institute, US
- Yao Lu (陆遥), Edge-preserving regularizations for ECT reconstruction in mesh domain, 中山大学

### 10:40-12:10 Session M2, Chair: Qing Ling (凌青)

- Yuan Yao (姚远), Some open problems in online algorithms, 北京大学
- Shiqian Ma (马士谦), Stochastic quasi-Newton methods for nonconvex stochastic optimization, 香港中文大学
- Yangyang Xu (徐扬扬), Convergence of block coordinate update method and its applications, University of Waterloo, Canada

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- Jianfeng Cai( 蔡剑锋 ), Low-rank structured matrix reconstruction from random measurements, University of Iowa, US
- Chunlin Wu (吴春林), Augmented Lagrangian method for total variation related problems over triangulated surfaces, 南开大学
- Jianwei Ma (马坚伟), Sparse representation of seismic data,哈尔滨工业大学
- Zelong Wang (王泽龙), Sparse modeling in reconnaissance and imaging, 国防科技大学

### 15:45-17:45 Session M4, Chair: Xin Liu (刘歆)

- Xiaoming Yuan (袁晓明), ADMM for linear programming, 香港浸会大学
- Qing Ling (凌青), Decentralized dynamic optimization through the alternating direction method of multipliers, 中国科技大学
- Caihua Chen (陈彩华), On the direct extension of ADMM for multi-block convex minimization problems, 南京大学
- Min Tao (陶敏), Constrained total variation deblurring and its ADMM-based fast algorithms, 南京大学

## December 23, Tuesday

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- Junfeng Yang (杨俊峰), A general inertial proximal point method for mixed variational inequality problem, 南京大学
- Wotao Yin (印卧涛), Convergence rates of operator splitting methods， UCLA, US
- Yafeng Liu (刘亚峰), Optimal resource allocation for wireless communications: complexity analysis and algorithm design, 中国科学院

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- Zaiwen Wen (文再文), A proximal gradient method for ensemble density functional theory, 北京大学
- Xin Liu (刘歆), A parallel line search subspace correction method for composite convex optimization, 中国科学院
- Mengdi Wang (王梦迪), Duality gap for large separable saddle point problems, Princeton University, US

## Lunch break

### 13:30-14:30, Session T3, Chair: Jianfeng Cai(蔡剑锋)

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- Guan Naiyang (管乃洋), Non-negative matrix factorization and its optimization, 国防科技大学

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- Hui Zhang (张慧), Variants of alternating minimization method with sublinear rates of convergence for convex optimization, 国防科技大学
- Tianyu Wu (吴天宇), A primal-dual forward-backward algorithm with nonstandard metrics, UCLA, US
- Xue Zhang (张雪), Proximal iterative hard thresholding methods for wavelet frame based image restoration, 上海交通大学
- Zhihua Zhao (赵志华), Adaptive projected gradient thresholding methods for constrained l_0 problems, 西安交通大学

## 16:10-17:10, visit the Tianhe Supercomputer

# 代表须知

[1] 会议地点：长沙延年世纪酒店(三一大道四方坪段)

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[2] 乘车线路：**会务组将派车接参会代表，请大家尽快提供航班、车次信息，并保持通讯畅通。**

[3] 会议报到：21 日全天可进行会议报到，请大家到酒店后，在大厅签到处签到，并领取会议资料。前往张家界的代表请在大厅签到处联系旅行社人员。

[4] **会议用餐**：21 日、22 日、23 日及 26 日会议安排统一用餐，校内参会学员只提供 22 日、23 日中餐。21 日及 26 日用餐为围席，**地点为延年世纪酒店三楼食如意-美满如意厅，其中 21 日中餐在 315 台，21 日晚餐在 318、319、320 台，26 日晚餐在 315、316 台，请参会代表凭红色代表证用餐，**工作人员凭绿色代表证用餐。**21 日中餐时间为中午 12 点至下午 1 点，21 晚餐时间为下午 6 点至 7 点，如您不能在上述时间内赶到会务组将不再安排**。22 日及 23 日用餐为自助餐，地点为延年世纪酒店一楼咖啡厅，**请大家凭资料袋内餐票用餐。**

[5] 代表及工作人员凭代表证和工作证进入会场，敬请各位代表务必保管好有关证件，会议室设在酒店**负一楼，请乘电梯直接下负一楼至延年世纪酒店多功能厅。**

[6] 为保证会场秩序，大会报告期间请将手机调至振动状态。

[7] **会议期间，如需开通房间长途电话与收费电视服务，请自行与总台联系，费用自理。**

[8] **房间内部分用品为收费用品，请您鉴别，如需消费，费用自理，其中一次性洗漱用品由会务组承担。**

[9] 酒店东侧约 200 米处有麦德龙超市，如需购物，可自行前往。

[10] 退房时间为当日 14:00，如超过 14:00 将加收半日房费，超过 18:00 收取全日房费。

[11] 23 日下午参观天河计算机车辆安排，**登车时间下午 4:10，地点：酒店楼前，车辆：ZG02063**（大客），返回时乘坐同一辆车

[12] 会议安排如有临时变动，请以组委会当日通知为准。

# 大会报告摘要集（按报告顺序）

## Continuum for Image Restoration

Bin Dong, University of Arizona / 北京国际数学中心

Image restoration, including image denoising, deblurring, inpainting, computed tomography, etc., is one of the most important areas in imaging science. In image restoration, wavelet frame based models, such as the analysis based model, and differential operator based models, such as variational and PDE models, have been widely used and proven successful in many applications. These approaches were developed through different paths and generally provided understandings from different angles. Since both approaches are to model the same type of problems with success, it is natural to ask whether wavelet frame based approach is fundamentally connected with variational/PDE based approach when we trace all the way back to their roots.

My talk is based on a series of three papers ([1-3] below). In [1], we established connections between wavelet frame transforms and differential operators in variational framework. In [2], we established their connections for nonlinear evolution PDEs. Based on [1,2], we proposed a new piecewise smooth image restoration model based on wavelet frames in [3], and linked it with a brand new variational model, a special case of which resembles, but is superior to, the well-known Mumford-Shah model. The connections established in [1-3] provide us with new insights and inspiring interpretations of both wavelet frame and differential operator based approaches, which enable us to create new models and algorithms for image restoration that combine the merits of both approaches. The significance of our findings is beyond what it may appear. In fact, our analysis and discussions in [1-3] already indicate that wavelet frame based approach is a new and useful tool in numerical analysis to discretize and solve variational and PDE models in general, which enriches the existing theory and applications of numerical PDEs, variational techniques, wavelet frames, etc.

**References**

[1]. J. Cai, B. Dong, S. Osher and Z. Shen, *Image restoration: total variation; wavelet frames; and beyond*, Journal of AMS, 25(4), 1033-1089, 2012.

[2]. B. Dong, Q. Jiang and Z. Shen, *Image restoration: wavelet frame shrinkage, nonlinear evolution PDEs*, and beyond, preprint, December 2013.

[3]. Jian-Feng Cai, Bin Dong and Zuowei Shen, *Image restorations: a wavelet frame based model for piecewise smooth functions and beyond*, preprint, April 2014.

## Retinex by Higher Order Total Variation $L^1$ Decomposition

Xiaoqun Zhang, 上海交通大学

In this paper we propose a reflectance and illumination decomposition model for Retinex based on high order total variation and $L^1$ decomposition. Based on the observation that illumination varies smoother than reflectance features, we propose a convex variational model which can effectively decompose the gradient field of observed image into salient edges and illumination field by using first and second order total variation regularization. The proposed model can be efficiently solved by a primal–dual splitting method. The tests performed on both gray scale and color images show the strength of the proposed model for applications to Retinex illusions, medical image bias field removal and color correction.

## Non-Rigid Point Cloud Registration Using Robust Sliced-Wasserstein Distance via Laplace-Beltrami Eigenmap

Rongjie Lai, Rensselaer Polytechnic Institute (RPI)

In this talk, I will discuss our recent development on computational models and algorithms for point clouds registration based on the optimal transport theory via Laplace Beltrami eigenmap. Our methods use robust sliced- Wasserstein distance, which is as the average of projected Wasserstein distance along different directions, and incorporate a rigid transformation to handle ambiguities introduced by the Laplace-Beltrami eigenmap. This method provides both generality and flexibility to handle general point clouds setting. By going from smaller *n*, which provides a quick and robust registration (based on coarse scale features) as well as a good initial guess for finer scale registration, to a larger *n*, our method also introduces an efficient, robust and accurate approach for multi-scale non-rigid point cloud registration.

## Edge-Preserving Regularizations for ECT Reconstruction in Mesh Domain

Yao Lu, 中山大学

The purpose of this study was to implement the continuous edge-preserving regularization rooted from traditional discrete Total Variation (TV) regularization for iterative ECT reconstruction in mesh domain to suppress image noise accumulation with increasing iteration number and thus to stabilize the reconstruction while preserving edges in the reconstructed images. In order to accomplish these aims we used reconstruction algorithms in mesh domains that employed TV priors applied in a continuous form. We established a continuous-to-discrete integral equation model for ECT projections and used it to derive edge-preserving regularization algorithm in mesh domain. A computationally efficient approach for the proposed continuous regularizations was derived for piecewise linear basis functions.

## Some Open Problems in Online Algorithms

Yuan Yao, 北京大学

In this talk, I would like to discuss some interesting yet open problems arising from online algorithms in ranking and learning. The first problem is to obtain error bounds in exponential probabilistic inequalities, which lead to almost-sure convergence as well as optimal in both convergence rates and condition number in constants. The second problem is related to stochastic approximations of sparsity regularization paths, e.g. stochastic linearized Bregman iterations with early stopping.

## Stochastic Quasi-Newton Methods for Nonconvex Stochastic Optimization

Shiqian Ma, 香港中文大学

In this talk, we discuss stochastic quasi-Newton methods for nonconvex stochastic optimization. We assume that only stochastic information of the gradients of the objective function is available via a stochastic first-order oracle (SFO). We firstly propose a general framework for stochastic quasi-Newton methods solving such kind of problems. This type of methods extends the classic quasi-Newton method for deterministic optimization problems to a stochastic setting with stochastic information of the function being used. Secondly, we propose a general framework for a class of randomized stochastic quasi-Newton methods in which the number of iterations conducted by the algorithm is a random variable. The worst-case SFO-calls complexities of these methods are analyzed. Thirdly, we propose two specific algorithms that fall into this framework: stochastic damped-BFGS method and stochastic cyclic Barzilai-Borwein method. Finally, we report some preliminary numerical results that demonstrate the efficiency of the proposed algorithms.

## Convergence of Block Coordinate Update Method and Its Applications

Yangyang Xu, University of Waterloo

In this talk, I will present a few different forms of block coordinate update (BCU) method and show/review their convergence results on both convex and nonconvex optimization problems. I will also give numerical results of different BCU methods, in particular on nonconvex optimization problems, and demonstrate that randomness is helpful to avoid local solutions.

## Low-Rank Structured Matrix Reconstruction from Random Measurements

Jianfeng Cai, University of Iowa

I will present some results on low-rank Hankel and Toeplitz matrix reconstruction from random measurements. In particular, I will give the lower bound of number of random Gaussian measurements for exact low-rank Hankel and Toeplitz matrix reconstruction. This will be applied to spectral compressed sensing and NMR spectrascopy and compared with existing methods.

## Augmented Lagrangian Method for Total Variation Related Problems over Triangulated Surfaces

Chunlin Wu, 南开大学

Total variation regularization has been proven very useful in image processing and computer graphics applications. Recently many efforts have been contributed to efficiently solve this type of problems which are non-differentiable. Augmented Lagrangian method is one of the most efficient methods. In this talk, we will discuss this method for total variantion related problems over triangulated surfaces, including image denoising and segmentation on surfaces, as well as surface denoising.

## Sparse Representation of Seismic Data

Jianwei Ma, 哈尔滨工业大学

In this talk, we will present two new methods for sparse representation of geophysical oil/gas exploration data. One is based on double sparse dictionary learning by seislet transform and data-driven tight frame, and another one is based on asymmetric Gaussian chirplet and match pursuit. The data interpolation and denoising will benifit from the sparse transform.

## Sparse Modeling in Reconnaissance and Imaging

Zelong Wang, 国防科技大学

Electronic reconnaissance and imaging are important methods to obtain information, where the quality of signal and image processing is of great importance. However, it is difficult to obtain the proper solutions to many inverse problems in signal and image processing for their ill-posedness. To make them well-posed, the sparseness, one of the most important regularizations, is usually introduced. In this talk, we mainly study three information processing problems, i.e. DOA estimation, image processing, and image reconstruction, from the viewpoint of sparseness. Firstly, the backgrounds of these problems are introduced and the sparse priors of them are explored. Secondly, the models are established, such as signal subspace model for DOA estimation, regularized sparse representation model for image processing, and sparse high-resolution reconstruction model for both optical and microwave imaging. Lastly, we give some possible works in the future: more accurate models, faster algorithms, and practical system design.

## ADMM for Linear Programming

Xiaoming Yuan, 香港浸会大学

In this talk, I will show that the well-known alternating direction method of multipliers (ADMM), which is mainly used for nonlinear convex programming models with separable structures, can be extremely efficient for solving the canonical linear programming model. The application results in a complexity of O(*mn*) in algorithmic implementation, where *n* is the variable dimensionality and *m* is the number of constraints.

## Decentralized Dynamic Optimization through the Alternating Direction Method of Multipliers

Qing Ling, 中国科学技术大学

We apply the alternating direction method of multipliers (ADMM) to optimize a dynamic objective function in a decentralized multi-agent system. At each time slot, agents in the network observe local functions and cooperate to track the optimal time-varying argument of the sum objective. This cooperation is based on maintaining local primal variables that estimate the value of the optimal argument and auxiliary dual variables that encourage proximity with neighboring estimates. Primal and dual variables are updated by an ADMM iteration that can be implemented in a distributed manner whereby local updates require

access to local variables and the most recent primal variables from adjacent agents. For objective functions that are strongly convex and have Lipschitz continuous gradients, the distance between the primal and dual iterates to their corresponding time-varying optimal values are shown to converge to a steady state gap. This gap is explicitly characterized in terms of the condition number of the objective function, the condition number of the network that is defined as the ratio between the largest and smallest nonzero Laplacian eigenvalues, and a bound on the drifts of the optimal primal variables and the optimal gradients. Numerical experiments corroborate theoretical findings and show that the results also hold for non-differentiable and non-strongly convex primal objectives.

## On the Direct Extension of ADMM for Multi-Block Convex Minimization Problems

Caihua Chen, 南京大学

In this talk, we consider the use of the extended ADMM for multi-block convex minimization problems. We present some sufficient conditions to ensure the convergence of the extended ADMM and give an example to demonstrate the divergence of the method. Possible convergent variants of the extended ADMM, including the ADMM with random permutation and the PADMM3c (by Yang, Sun and Toh), are also discussed.

## Constrained Total Variation Deblurring and its ADMM-Based Fast Algorithms

Min Tao (陶敏), 南京大学

The total variation (TV) model is attractive in that it is able to preserve sharp attributes in images. However, the restored images from TV-based methods do not usually stay in a given dynamic range, and hence projection is required to bring them back into the dynamic range for visual presentation or for storage in digital media. This will affect the accuracy of the restoration as the projected image will no longer be the minimizer of the given TV model. In this paper, we show that one can get much more accurate solutions by imposing box constraints on the TV models and solving the resulting constrained models. Our numerical results show that for some images where there are many pixels with values lying on the boundary of the dynamic range, the gain can be as great as 10.28 decibel in the peak signal-to-noise ratio. One traditional hindrance using the constrained model is that it is difficult to solve. However, in this paper, we propose using the alternating direction method of multipliers (ADMM) to solve the constrained models. This leads to a fast and convergent algorithm that is applicable for both Gaussian and impulse noise. Numerical results show that our ADMM algorithm is better than some state-of-the-art algorithms for unconstrained models in terms of both accuracy and robustness with respect to the regularization parameter.

## Conditional Gradient Sliding for Convex Optimization

Guanghui Lan, University of Florida

We introduce a new conditional gradient type method for convex optimization by utilizing a linear optimization oracle to minimize a series of linear functions over the feasible set. Different from the classical conditional gradient method, this algorithm can skip the computation of gradients from time to time, and as a result, achieve the optimal rate of convergence in terms of not only the number of calls to linear optimization oracle, but also the first-order oracle. We also develop stochastic variants of this algorithm for solving stochastic optimization problems in an optimal manner. To the best of our knowledge, this is the first time that optimal projection free (stochastic) first-order method of this type has been presented in the literature.

## A General Inertial Proximal Point Method for Mixed Variational Inequality Problem

Junfeng Yang, 南京大学

In this paper, we first propose a general inertial proximal point method for the mixed variational inequality (VI) problem. Based on our knowledge, without stronger assumptions, convergence rate result is not known in the literature for inertial type proximal point methods. Under certain conditions, we are able to establish the global convergence and a $o(1/k)$ convergence rate result (under certain measure) of the proposed general inertial proximal point method. We then show that the linearized alternating direction method of multipliers (ADMM) for separable convex optimization with linear constraints is an application of a general proximal point method, provided that the algorithmic parameters are properly chosen. As byproducts of this finding, we establish global convergence and $O(1/k)$ convergence rate results of the linearized ADMM in both ergodic and nonergodic sense. In particular, by applying the proposed inertial proximal point method for mixed VI to linearly constrained separable convex optimization, we obtain an inertial version of the linearized ADMM for which the global convergence is guaranteed. We also demonstrate the effect of the inertial extrapolation step via experimental results on the compressive principal component pursuit problem.

## Convergence Rates of Operator Splitting Methods

Wotao Yin, University of California, Los Angeles

Splitting schemes are a class of powerful algorithms that solve complicated monotone inclusions and convex optimization problems that are built from many simpler pieces. They give rise to algorithms in which the simple pieces of the decomposition are processed individually. This leads to easily implementable and highly parallelizable algorithms, which often obtain nearly state-of-the-art performance. This talk overviews the convergence rates of several general splitting algorithms and provide examples. In some cases, we prove the tightness of our results.

# Communications: Complexity Analysis and Algorithm Design

Yafeng Liu, 中国科学院

Resource allocation is a fundamental problem in the design of wireless communication systems. The mutual interference among users, which is a major factor of limiting the performance of communication systems, can be effectively mitigated by carefully allocating wireless resources such as transmission power, transmission waveforms, and frequency bands. Most of the resource allocation problems arising from wireless communications can be formulated as optimization problems. On one hand, these optimization problems are often non-convex and highly nonlinear; on the other hand, these problems have their own special structures such as hidden convexity and separability. In this talk, we shall focus on two resource allocation problems, especially on characterizing the computational complexity of these problems, and designing customized algorithms for solving these problems by the use of their special structures.

In the first part, we talk about the max-min fairness linear transceiver design problem for a multi-user multi-input multi-output (MIMO) interference channel. This problem can be formulated as the maximization of the minimum signal to interference plus noise ratio (SINR) utility, subject to individual power constraints at each transmitter. We prove that, if the number of antennas is at least two at each transmitter (receiver) and is at least three at each receiver (transmitter), the max-min fairness linear transceiver design problem is computationally intractable as the number of users becomes large. We then propose two iterative algorithms to solve the max-min fairness linear transceiver design problem. The transceivers generated by these algorithms monotonically improve the min-rate utility and are guaranteed to converge to a stationary solution.

In the second part, we talk about the joint power and admission control (JPAC) problem for a multi-user single-input single-output (SISO) interference channel. The goal is to support a maximum number of links at their specified SINR targets while using minimum total transmission power. Various convex approximation deflation approaches have been developed for the JPAC problem. We propose an effective polynomial time non-convex approximation deflation approach for solving the problem. The proposed approach is based on the non-convex $l_q$ ($0<q<1$) approximation of an equivalent sparse $l_0$ reformulation of the JPAC problem. Numerical simulations show that the proposed approach significantly outperforms the existing convex approximation approaches in terms of the number of supported links and the total transmission power, particularly exhibiting a quite good performance in selecting which subset of links to support.

## A Proximal Gradient Method for Ensemble Density Functional Theory

Zaiwen Wen, 北京国际数学研究中心

The ensemble density functional theory is valuable for simulations of metallic systems due to the absence of a gap in the spectrum of the Hamiltonian matrices. Although the widely used self-consistent field iteration method can be extended to solve the minimization of the total energy functional with respect to orthogonality constraints, there is no theoretical guarantee on the convergence of these algorithms. In this paper, we first eliminate the dependence on the fractional occupancies and establish an equivalent model with a single variable and a single spherical constraint. Then a proximal gradient method is developed by keeping the entropy term but linearizing all other terms in the total energy functional. Convergence to the stationary point is established. Numerical results in the KSSOLV toolbox under the Matlab environment show that they can outperform SCF consistently on many metallic systems.

## A Parallel Line Search Subspace Correction Method for Composite Convex Optimization

Xin Liu, 中国科学院

We investigate a parallel subspace correction framework for composite convex optimization. The variables are first divided into a few blocks based on certain rules. At each iteration, the algorithms solve a suitable subproblem on each block simultaneously, construct a search direction by combining their solutions on all blocks, and then identify a new point along this direction using a step size satisfying the Armijo line search condition. They are called PSCLN and PSCLO, respectively, depending on whether there are overlapping regions between two immediately adjacent blocks of variables. Their convergence is established under mild assumptions. We compare PSCLN and PSCLO with the parallel version of the fast iterative thresholding algorithm and the fixed-point continuation method using the Barzilar-Borwein step size and the greedy coordinate block descent method for solving the $l_1$-regularized minimization problems. Our numerical results show that PSCLN and PSCLO can run fast and return solutions no worse than those from the state-of-the-art algorithms. It is also observed that the overlapping domain decomposition scheme is helpful when the data of the problem has certain special structures.

## Duality Gap for Large Separable Saddle Point Problems

Mengdi Wang, Princeton University

We consider the saddle point problem involving the sum of a large number of component functions. Although the component functions are not necessarily convex-concave, we can show that their large sum is approximately convex-concave. We derive a duality gap estimate for this saddle point problem, which suggests that solving the maximin problem provides a fairly good approximation for the minimax problem.

## An efficient algorithm for a class of singly linearly constrained quadratic programs with a variable box

Yongjin Liu, 沈阳航空大学

This paper focuses on a class of singly linearly constrained quadratic programs with a variable box. In this paper, a new efficient algorithm based on parametric approach and secant approximation is proposed for finding the closed-form solution of this class of these problems. We design efficient implementations for our proposed algorithm to solve a variety of instances including the problem of computing the metric projection over the epigraph of the weighted Ky Fan k-norm functions and compare its performance with some public softwares. Computational results on large-scale random test problems are also reported in order to evaluate the efficiency of our algorithm.

## Variants of Alternating Minimization Method with Sublinear Rates of Convergence for Convex Optimization

Hui Zhang, 国防科技大学

The alternating minimization (AM) method is a fundamental method for minimizing convex functions whose variable consists of two blocks. How to efficiently solve each subproblems when applying the AM method is the most concerned task. In this paper, we investigate this task and design two new variants of the AM method by borrowing proximal linearized techniques. The first variant is very suitable for the case where half of the subproblems are hard to be solved and the other half can be directly computed. The second variant is designed for parallel computation. Both of them are featured by simplicity at each iteration step. Theoretically, with the help of the proximal operator we first write the new as well as the existing AM variants into uniform expressions, and then prove that they enjoy sublinear rates of convergence under very minimal assumptions.

## A Primal-Dual Forward-Backward Algorithm with Nonstandard Metrics

Tianyu Wu (吴天宇), University of California, Los Angeles

Many optimization problems can be formulated in a primal dual setting. In this talk we will focus on a forward backward splitting scheme applied to the KKT condition of the primal dual problem. With the help of nonstandard metrics, we can get algorithms with easy to solve subproblems. The proof of convergence is similar to the standard metric case. It will be illustrated that various choice of nonstandard metrics will lead to different algorithms. We will also show that many existing algorithms can be analyzed in this general scheme.

## Proximal Iterative Hard Thresholding Methods for Wavelet Frame Based Image Restoration

Xue Zhang (张雪), 上海交通大学

We consider a proximal iterative hard thresholding algorithms for $L_0$-norm regularized wavelet frame balanced approach for image restoration, based on recently studied Kurdyka-Lojasiewicz property. In particular, we study the convergence of two algorithms, namely proximal iterative hard thresholding (PIHT) algorithm and extrapolated proximal iterative hard thresholding algorithm for solving this class of problems. We first demonstrate that, given an initial point, the sequence generated by PIHT will converge to a local minimizer of the objective function and the sequential error rate is at $o(1/k)$. Then, we show the convergence of EPIHT by proving that the sequence generated by this algorithm is bounded, and any accumulation point of the sequence is a local minimizer of the objective function. Furthermore, we conduct numerical experiments on compressive sensing sparse signal reconstruction and wavelet frame based image restoration, such as CT reconstruction, image deblurring and parallel MRI image reconstruction, to demonstrate the improvement of $L_0$-norm based regularization models as well as the effectiveness of the proposed algorithms compared some prevailing $L_1$-norm based models and algorithms. We also show in some numerical experiments that the iteration complexity of the proposed EPIHT is lower than that of PIHT.

## Adaptive Projected Gradient Thresholding Methods for Constrained $l_0$ Problems

Zhihua Zhao, 西安交通大学

In this paper, we propose and analyze Adaptive Projected Gradient Thresholding (APGT) methods for finding sparse solutions of underdetermined linear systems with equality and box constrains. The general convergence will be demonstrated, and in addition we are able to find the bound of the number of iterations in some special cases. Under suitable assumptions, it is proved that any accumulation point of the sequence generated by the APGT methods is a local minimizer of the underdetermined linear systems. Moreover, the APGT methods, under certain conditions, indeed find all -sparse solutions for accurate measurement cases and guarantee the stability and robustness for flawed measurement cases. Numerical examples are presented to show the accordance with theoretical results in compressed sensing and verify high out-of-sample performance in index tracking.

# 国防科技大学理学院数学与系统科学系简介

国防科技大学是一所直属中央军委领导的军队综合性大学，是国家“985 工程”和“211 工程”重点建设院校。学校的前身是 1953 年创建于哈尔滨的中国人民解放军军事工程学院，即著名的“哈军工”。

国防科学技术大学理学院数学与系统科学系的渊源，可上溯至 “哈军工”时期，孙本旺、卢庆骏等知名数学家曾为之奠基培上第一锹土。1978 年由钱学森先生倡导组建了国防科学技术大学系统工程与数学系，1999 年成立数学与系统科学系，隶属理学院。经过几代人不懈探索和艰苦奋斗，构建了较完善的学科体系，坚持以“问题驱动的数学研究”为指导，以应用为牵引，以前沿理论研究为契机，形成了一批理论与应用相结合、体现出浓厚的“国防”与“基础前沿”特色的基础与应用研究方向，在全国具有良好的学术声誉。

***学 科 建 设***

我系拥有数学和系统科学两个一级学科，其中数学学科拥有一级学科博士授予权和数学博士后科研流动站，纳入学校“十二五”重点建设综合化学科体系，为湖南省“十二五”一级重点学科；系统科学拥有一级学科硕士授予权、系统分析与集成二级学科博士授予权和系统科学博士后科研流动站，纳入学校“十二五”重点建设优势跃升工程，为湖南省“十二五”一级重点学科。拥有国家级教学团队1个，国家视频公开课、国家级精品课程、国家精品资源共享课程等4门，国家规划教材2部，湖南省精品课程6门，获军队育才奖25项。获国家级教学成果奖二等奖2项、军队教学成果奖一等奖3项。数学建模、数学课程建设及竞赛等在全国具有较大影响，高等数学为首批中国大学MOOC平台课程。“十一五”和“十二五”条件建设总投资超过2000万元。建有全军数理实验教学中心、湖南省大学生创新训练基地、数学技术实验室，目前正在建设二代导航全球连续监测评估数据中心与分析中心、数理学科研究生创新平台。

***科 学 研 究***

我系长期承担 973、863、国防预研等重大科研项目和国家自然科学基金、国防预研基金等基础研究项目，科研成果以其服务于军队战斗力提高而颇有影响，且为媒体广泛报导。近五年来，承担国家级项目 60 余项，科研经费近 7000 万元；多名教师入选国家级创新团队，拥有省级创新团队，获省部级自然科学及科技进步一二等奖 20 余项，中国图书奖等 2 项，多篇论文进入 ESI 所属学科被引用次数前 10％。

***师 资 队 伍***

全系现有教授 21 人，副教授 32 人（包括国家教学名师 1 人、国家高层次人才特殊支持计划高等学校教学名师 1 人、全国优秀教师 1 人、国家百千万人才工程第一、二层次人选 1 名、973 首席科学家 1 人、教育部新世纪优秀人才 4 名，享受国务院政府特殊津贴 6 人次），另有特聘院士 1 人，兼职教授 13 人（其中科学院院士 3 人，长江学者千人计划 1 人，国家教学名师 3 人）。拥有博士生导师 13 人，硕士生导师 28 人。已形成了一支学术水平高、结构合理、团结拼搏、奉献求实、在国内外有较大影响的教师队伍。

***人 才 培 养***

人才培养始终保持高起点、高水平。已同MIT、柯朗数学研究所、牛津大学、剑桥大学、美国

纯粹与应用数学研究所、美国加州伯克利分校等国外知名院校建立了稳固的学术交流渠道。多次承办相关专业的国际和全国性学术会议，及教育部和国家自然科学基金委的全国研究生暑期学校等，反响很好。每年选送一批优秀研究生赴国外高水平大学进行联合培养和攻读学位。近年来，在国际及全国数学建模竞赛、全国数学竞赛中取得了优异成绩，获得国际特等奖4项，特等奖提名1项，一等奖多项，在国内有较大影响。指导学生在全国创新竞赛获“挑战杯”一等奖，并多次获国家创新计划资助。多篇论文获得全国百篇优秀博士论文提名、军队或湖南省优秀博士、硕士论文。

***招 贤 纳 士***

为培养高素质新型军事人才，研究国防关键技术和先进武器装备，欢迎军队在职干部、军队院校和普通高校应届毕业生报考我系硕士、博士研究生，或来我系从事博士后研究，我校接收推荐免试生。我系招收的研究方向包括微分方程与动力系统、代数结构与编码密码理论、信息处理的数学理论与应用、大规模科学与工程计算、随机分析与统计、组合数学与最优化、复杂系统理论、大系统性能分析与评估、网络科学与大数据分析，愿勇于攀登世界科技高峰的青年才俊，在三湘四水环抱下的国防科大实现强军兴国的远大抱负，为献身国防和军队建设事业不断进取创新。

**硕士研究生**

条件

军队在职干部:经所在部队军级单位政治部审批,持师级单位干部部门介绍信.

军队院校应届本科毕业生和国防生:培养目标应为非指挥干部,报名时须出具不参加分配的证明.

普通高校应届本科毕业生:本科就读院校应为“211 工程”院校,毕业时能取得本科学历和学术学位,年龄不超过 24 周岁,只能报考理工科.

全日制专业学位硕士(工程硕士、公共管理硕士)仅限部队在职干部报考.

地方硕士研究生：招收普通高校应届本科毕业生和地方在职人员，考生录取后不参军.

待遇

军人学员工资 3800 元/月,伙食补贴 450 元/月,每年一次公费探亲；

非军人学员学费 8000 元/年,应届学员不收取学费，基本生活费由导师承担，1000 元/月（每年按 10 个月计）。

参军计划由军队总部直接下达，其中女生参军名额有限，请慎重报考。地方研究生学费执行湖南省物价局核定的学费标准，我校参照国家研究生培养机制改革的有关政策，实行研究生奖、助学金制度。

接收地方高等院校推荐免试生。

**博士研究生**

条件

军队非应届在职干部：由师（旅、团）级单位推荐，军级单位政治部审批，报军区级单位政治部干部部门备案，持师级单位干部部门介绍信报名.

军队院校应届硕士毕业生：报名时须出具不参加分配的证明，并明确录取类别为定向或非定向。

地方报考人员：报考国家计划内博士生考生的年龄应不超过 45 周岁，考生录取后不参军.

待遇

军人学员工资 4800 元/月,伙食补贴 450 元/月,每年一次公费探亲；

非军人学员学费 12000 元/年,应届学员不收取学费，基本生活费由导师承担，2000 元/月（每年按 10 个月计）。

参军计划由军队总部直接下达，其中女生参军名额有限，请慎重报考。地方研究生学费执行湖南省物价局核定的学费标准，我校参照国家研究生培养机制改革的有关政策，实行研究生奖、助学

金制度。

接收地方高等院校推荐免试生。

**博士后**

条件

博士毕业期限一般不得超过两年；能够保证每年在站时间不少于 10 个月，在职人员不得兼职从事博士后研究工作。要求有熟练阅读专业书籍、文献和撰写论文及学术交流的英语能力；熟练掌握计算机操作及应用；具有较强的科学研究能力和潜力。

待遇

统招统分,地方脱产人员可每月发放生活补助，无住房博士进站时,一次性发放安家补助，除本校人员外,每年实际在站时间超过 10 个月且中期考评称职者可享受岗位津贴。

我们求贤若渴，热情欢迎国内外中青年才俊来我系工作，这里是人民解放军高素质新型军事人才的摇篮，是军队高级指挥军官的培训基地，是国防关键技术和先进武器装备研究的重要基地，更是有志于攀登世界科技高峰，献身国家和军队建设的青年才俊实现人生理想的热土！

**学科拔尖人才**

条件

具备服现役的基本条件;具有博士学位;年龄不超 40 周岁;担任过国内外著名高校、科研院(所)副教授以上职务,或已取得高级专业技术资格,或近 5 年在国际核心期刊上发表过具有重要影响的学术论文，或获得过在国际上具有重要影响的科学技术奖项.

待遇

参军入伍,提供公寓住房一套;应聘者为现就职于海外知名大学的教授及相应职务者,国内"985 工程"高校教授或相应职务者,国家杰出青年科学基金获得者,新世纪优秀人才支持计划入选者提供科研启动和安家费；其他类型应聘者提供科研启动和安家费。

**青年学术骨干**

条件

具备服现役的基本条件;国内“985 工程”高校优秀应届博士毕业生且第一学历为国内“985 工程”高校本科毕业;优先接收 SCI 论文高产作者、具有海外留学经历和“985 工程”高校保送直接攻读博士学位的毕业生.

待遇

参军入伍，按照军队相关规定确定职级及工资待遇，并提供相应职级公寓住房一套；提供科研启动和安家费，参照军队生长干部攻读博士学位期间工资待遇标准一次性资助。

**军队文职人员**

条件

应具有高等学校全日制本科以上学历,教育、科研、工程、医疗专业技术人员还应具有相应学位;应具有岗位职业、专业技术资格;应聘初级专业技术岗位不超过 35 周岁,中级专业技术岗位不超过 40 周岁,高级专业技术岗位不超过 50 周岁.

待遇

薪酬待遇，总体待遇按国家、军队管理有关规定执行，具体待遇视能力及贡献确定。在年终总结时，当年工作成绩最突出的予以表彰。

**聘用人员**

条件

招聘对象自愿为军队和学校建设服务，应符合征集公民服现役的政治条件；年龄、学历、专业方向等基本情况符合设定岗位基本要求，且身体健康。

待遇

协商确定薪酬待遇，总体待遇参照学院从事同类工作及相应级别的军队文职人员待遇，签订劳动合同，有“五险一金”。

## 主要研究方向和研究成果

### *1、基 础 数 学*

**代数结构理论及其应用**

代数结构理论及其应用是我校基础数学研究中的一个重要研究方向。该方向主要研究矩阵分析与应用、环模理论、同调代数及代数数论，取得了系列成果。该方向拥有教授 1 人，副教授 2 人，先后主持了包括国家自然科学基金和省部级项目在内的科研课题 8 余项。先后获部委级科技进步一等奖、二等奖共 3 项，三等奖 1 项。相关结果发表在 Pacific J. Mathematics、J. Pure & App. Alg.等期刊上。

**微分方程与动力系统**

该方向主要研究泛函微分方程和反应扩散方程几何理论及在生物数学中的应用、流体中的非自治/随机偏微分动力学方程的动力学与遍历性、脉冲微分方程与微分包含等问题。该方向拥有一支精干高效、学术造诣深的学术队伍，拥有美国数学评论评论员 2 名，1 人享受国务院特殊津贴，1 人为全国百篇优秀博士论文(提名)作者，全国优秀教师 1 名，先后主持了包括国家自然科学基金和省部级项目在内的科研课题 10 余项。建立了单值-集值 Krasnoselskii-Schaefer 型不动点定理,部分回答了 Singh-Mishra 公开问题；建立了非光滑区域上随机动力系统的吸引子的几何理论；获得了脉冲参数影响脉冲微分系统的动力学行为的模式特点等，研究成果发表在 Proc.Amer.Math.Soc，Fuzzy Sets and Systems， Physica D, Discr.Cont.Dynam. Syst, J.Math.Biol.,Dynam of PDE， JMAA，Nonlin.Anal.，数学学报，中国科学等国内外知名杂志上，出版教材、专著 5 部。4 篇论文进入 ESI 所属学科被引用次数前 10%。

**几何拓扑**

重点研究流形的几何和拓扑性质。在微分几何方面重点研究 Yang-Mills-Higgs 热流的几何分析性质，建立在 Atiyah-Bott 意义下的等变 Morse 理论并计算相应的拓扑不变量；研究算子的指标理论，特别是在 Orbifold 上的指标理论及应用。在辛拓扑方面，开展国际上热门的 Gromov-Witten 不变量理论以及 FJRW 理论的研究，重点研究两种理论的联系，并将其应用于镜像对称猜想。同时，开展相关理论成果在实际上的应用。该方向目前拥有 2 名人员，在高水平杂志上发表论文 10 余篇。在 Yang-Mills-Higgs 热流的存在性和收敛性，2 维 orbifold 上 Cauchy-Riemann 算子的指标计算等领域取得了一些研究成果。

### *2、应 用 数 学*

**编码密码理论及其应用**

纠错编码和密码学是信息科学中两个重要的学科方向，前者是保障信息在通信过程中的可靠性，后者是保障信息在通信过程中的安全性。该方向主要研究纠错编码理论、序列密码、分组密码和 Hash

函数的设计与分析理论，取得了许多成果，近五年来，承担 973 专题、863 课题、国家密码基金和国家自然科学基金等 30 余项科研项目，项目总经费 800 余万元。在《IEEE Transactions on Information Theory》、《SIAM J.Discrete Mathematics》、《Science in China》、FSE、SAC 、SETA 等国内外重要的学术刊物和学术会议上发表学术论文百余篇。出版了国内首部专门讲述分组密码攻击方法的著作。2 篇论文进入 ESI 所属学科被引用次数前 10%。与国家密码管理局认可的商用密码生产单位密切合作，开发出数字签章系统 SJY105、证书认证系统 SJY105、数据加密算法 RD、数据压缩算法 RAY-Period 等商用密码产品。该方向近年来获部委级科技进步二等奖 1 项和三等奖 2 项，霍英东优秀青年教师奖 1 项。

**信息处理的数学理论与应用**

主要面向现代战争中提出的大量的感知信息处理问题，研究其中具有共性的数学理论并最终用于解决实际问题。在“图像数据建模与超分辨处理”、“压缩感知理论”、“信息表示超完备基理论”、“数学定位理论”方面达到国际前沿水平，并形成若干典型应用；围绕“几何分析及在成像处理中的应用”，开展重大基础研究和交叉研究。该方向拥有一支学术造诣高、能把握学术前沿的研究群体，其中，教授 4 人，博士生导师 2 人。学术带头人王正明为国家百千万人才工程一、二层次人选，全国百篇优秀博士论文作者，中国数学学会理事，教育部教学指导委员会委员。2 人享受政府特殊津贴。近 5 年来，承担了包括 863 和国家自然科学基金在内的科研课题 19 项。在 IEEE，Science in China 等国内外知名杂志上发表高水平学术论文百余篇，出版教材、专著 7 部。

**组合数学与最优化**

着重研究数学、计算机、军事、管理、生物、网络等领域提出的众多离散结构和优化问题，主要研究方向包括组合计数、组合优化、复杂网络优化分析、最优化理论与算法、随机图与网络、随机规划、博弈论等。目前该方向有教授 2 人、副教授 4 人（其中硕士生导师 3 人），另有 1 位兼职博士生导师。近年来，该团队在科学研究水平、人才培养质量等方面取得一系列成绩。在科学出版社等出版专著教材 10 多部，其中包括在国内较早出版且具有一定影响力的《拟阵》、《整数规划》、《网络算法与复杂性理论》等。在 Electron. J. Combin., Discrete Math., Journal of Graph Theory 等国际专业期刊上发表 SCI 论文 10 余篇，在《数学进展》、《运筹学学报》等国内核心期刊上发表学术论文 100 余篇，其中 SCI 论文“Constructive lower bounds on classical multicolor Ramsey numbers”进入 ESI 排名前 10%。承担国家重大基础研究项目、国家自然科学基金项目、武器装备预研项目、国防科学技术大学预研项目等 10 余项。

## ***3、计 算 数 学***

该方向拥有一个研究领域广泛、实力雄厚的学术团队，其中教授 7 人，博士生导师 4 人，具有博士学位的教员达 90%。拥有全国百篇优秀博士论文作者 1 名，全国计算数学学会理事 1 名，全军优秀教师 1 名，1 人获军队育才奖金奖、4 人获军队育才奖银奖，获专利 1 项，部委级科技进步奖二等奖 2 项、三等奖 1 项。学术带头人成礼智教授为全国百篇优秀博士论文作者，主要学术骨干曾赴美国 New York 州立大学、柯朗数学研究所、新墨西哥大学、新加坡南洋理工大学等大学交流访问。

**信息处理中的新型算法理论与应用**

根据特定信号处理问题，在空间、时间以及频率域内提出混合变换理论与算法并建立相应的几何多尺度、多分辨数学模型；借助于新一代小波分析与偏微分方程理论，建立瞬时、突变信号的统一处理模型；研究整数变换理论，建立低复杂度、低存储、实时处理系列算法。该方向已培养全国百优博士论文作者 1 人、湖南省及军队优秀硕博士论文作者 5 人、相关成果成功应用于某星载光学成像系统，获部委级科技进步奖 2 项，出版教材 6 部，累计发表学术论文百余篇，在军内及国内具

有一定影响力。

**面向高性能计算平台的数值线性代数理论与算法**

着重研究高性能计算平台上高置信度、极小通信数值代数库的设计、实现和分析，为基于大规模计算的各类军事应用提供共性支持。近年来，依托国家自然科学基金创新群体项目及天河高性能计算平台，系统研究了各种矩阵运算的极小通信模型、无误差变换与补偿算法的高精度并行计算，在特征值与奇异值计算的并行数值算法、大尺度高敏感多项式函数值的估计、大尺度长时程高精度并行数值模拟等方面取得了系列突破。该方向的研究成果曾获国防科工委科技进步二等奖，相关理论结果发表在 SIAM J. Sci. Comput., Numer. Math.等计算数学顶级期刊上。

**偏微分方程数值解及其应用**

研究飞行器在复杂流动场中的高精度数值模拟、复合材料物质机理的多尺度计算等，通过突破非结构网格生成、保结构数值算法、辛与多辛几何算法、有限元设计、再生核空间构造等核心问题，为武器设计和试验提供快速可靠的数字化模拟算法。构造出一致高阶精度的非结构网格大粒子有限体积方法，提出了一种新型的三维约束非结构网格生成方法，给出了基于小波配点方法、拟谱方法的辛与多辛算法，研究获国家自然科学基金重大研究计划培育项目支持，相关结果发表在 J.Comput. Phy. 和 SIAM J. Sci. Comput.等期刊上。

**电磁拓扑理论与复杂电磁场的数值模拟**

应用拓扑学和图论以及现代计算数学（如时域与频域有限差分、有限元等）的理论与方法，研究复杂电磁场的拓扑模拟和计算，分析和预测电子系统内部的电磁耦合问题，进而研究有害电磁信号转化为电子系统误码率的机理。目前已得到了两阻抗和多阻抗场路耦合的频域和时域的解析解，提出了基于多步迭代电磁拓扑方法研究外部干扰源与子系统之间的电磁交互作用。该方向的研究得到国家自然科学基金和国防预研基金等多个项目的支持，相关理论结果发表在 SIAM J. Matrix Anal. & Appl.、J. Math. Anal. & Appl.等期刊上。

## *4、统 计 学*

重点开展高维统计分析、大数据统计分析以及统计数据深度等方面的研究。在高维统计分析方面，主要研究高维数据的维数约简、特征提取、相关分析等研究；在大数据统计分析方面主要开展大数据的内蕴结构发现、大数据的统计抽样方法等研究，同时开展有效数据筛选、趋势预测等应用研究；在统计数据深度方面，主要研究基于再生核 Hilbert 空间的数据深度计算方法，同时开展基于统计深度的文本排序等应用研究。该方向目前拥有 6 名成员，其中教授 2 名，博士生导师 1 名，硕士生导师 2 名。近 5 年来，发表 SCI 二区以上论文 10 余篇。1 篇论文进入 ESI 所属学科被引用次数前 10％ 。在高维数据维数约简、统计数据深度分析等方面取得了一些研究成果，形成了一定的影响力。

## *5、系 统 科 学*

系统科学为一级学科。以三类系统（装备系统，网络系统，地球系统）为依托，针对系统的复杂性和不确定性，以数学建模、仿真与计算为手段，结合数据驱动，解决三类系统中的科学技术问题，同时提炼系统科学共性基础理论，展开复杂系统理论和应用研究。下设“系统理论”、“系统分析与集成”两个二级学科和“网络科学与大数据分析”交叉研究中心。多年来，坚持问题驱动，形成了“复杂系统理论”、“大系统性能分析与评估”、“网络科学与大数据分析”等理论与应用相结合、特色突出的学科方向。

该方向拥有一个实力非常雄厚的学术研究团队，教授 6 人，副教授 5 人，博士生导师 4 人，形成了一支以国家教学名师领衔教学、重大专项专家与 973 首席科学家领衔科研的教学科研型师资队伍。拥有国家级教学名师 1 名、“国家高层次人才特殊支持计划”教学名师（高等学校）1 名、“973”首席科学家 1 名、国家重大专项及总装专业技术专家组专家 4 人次、教育部新世纪优秀人才 2 名，入选全国创先争优先进个人、湖南省 121 人才支持计划、享受国务院政府特殊津贴 3 人次。学术骨干多次赴美国 MIT、OSU、英国帝国理工、Warrick 大学等交流访问。该学科以问题驱动，围绕复杂系统设计、建模、分析与评估，取得了大批高水平研究成果。其支撑的设备经费规模达亿元以上，产生了巨大的社会和经济效益。近 5 年，承担 973、国家重大专项等国家级科研项目 40 余项，项目经费 5000 余万元。获国家发明专利 3 项，国防发明专利 3 项，省部级自然科学奖和科技进步奖一等奖 4 项、二等奖 7 项。出版学术专著 7 部。获省部级教学成果奖一等奖 1 项，二等奖 1 项。4 篇论文进入 ESI 所属学科被引用次数前 10%。

**复杂系统理论**

主要研究成像数据、网络数据、定位数据等驱动的复杂系统建模、处理与分析理论，包括多源异质数据融合理论与技术、复杂系统的非线性行为特性、复杂海量信息系统的建模与处理等。其中航天飞行器跟踪数据融合处理研究技术水平处于国内领先水平，形成了系统的理论和方法，在研发、测控设计总体、应用部门等得到了广泛深入的应用，解决了一系列关键难题，取得显著的社会效益。压缩感知理论技术、海量数据分析等方面的研究水平处于全国前列。创造性提出了一系列遥感图像处理的新模型和新方法，为遥感图像性能提高做出了突出成绩。多次受邀在国际、国内重要会议上作大会报告。近五年来，该方向获省部级科技进步奖一等奖 1 项、二等奖 3 项，承担了武器装备重大探索项目、国家自然科学基金、武器装备预研项目等国家级项目近 30 项，在 SCI 数学类、工程技术类以及物理类的 I 区和 II 区期刊上发表论文近 20 篇，出版专著 3 部。

**大系统性能分析与评估**

该方向重点研究系统性能分析、设计与评估，以数学建模、仿真与计算为主要手段，结合数据驱动，进行复杂系统不确定性分析，系统试验设计、分析与评估，多导航系统性能监测与评估，航天器系统故障诊断与延寿管理及评估，非标准信息系统建模与信息处理等研究。提出了全测速定位原理，为新测控体制的建立奠定了理论基础，产生了巨大的社会和经济效益；在装备试验设计和评估、卫星有效载荷的在轨试验性能综合评估、卫星联合定轨及姿态高精度估计、编队卫星高精度相对位置确定、航天器系统故障诊断方面，研究处于国内先进水平，获得应用部门的高度评价。近年来，该方向获省部级科技进步奖一等奖 3 项、二等奖 4 项，承担国家重大专项和国家自然科学基金项目等 20 余项，发表高引用 SCI 论文多篇，出版专著 4 部。

## ***6、交 叉 学 科***

**网络科学与大数据分析**

该新兴交叉学科方向以数据驱动为主要手段，结合为数学建模、仿真与计算，拟在复杂网络的几何表示理论、大尺度网络动力学机制研究、大数据网络中的高性能计算等基础理论方面进行研究，超越传统图论表示局限，结合我校高性能计算平台建立适用于大规模网络动力学分析的高效能计算方法，并重点在网络大数据情报分析应用方面取得突破。其中，复杂网络的几何表示理论主要是把复杂网络归结为图、超图的性质研究；大尺度网络动力学机制主要探讨基于网络嵌入伪黎曼流形，用严格的数学理论解释网络的一般规律；基于大数据环境下复杂网络计算问题主要着眼于超大规模、高维与稀疏等特点，运用稀疏分析、并行与分布式计算等技术，结合网络分割、超图理论等进行高性能计算研究，建立系统中不确定因素的表示模型，研究复杂系统的系统结构和演化规则。同时开

展复杂数据中信息挖掘和适应系统不确定性稳健算法及应用研究。重点开展等方面的研究。该方向目前有教授 3 人，副教授 2 人，已发表高水平 SCI 论文 30 余篇，并且受到 973 项目和校交叉学科重点项目支持。

**国防科技大学理学院数学与系统科学系人才招聘需求**

| 类别 | 专业 | 学历 | 研究方向 | 需求 | 备注 |
|---|---|---|---|---|---|
| 特招入伍 | 数学、系统科学 | 博士研究生 | 数学、系统科学各研究方向（统计学、几何学、网络科学、运筹学、复杂系统理论优先） | 2 | 国外学位者，具有副高以上或相当职称，或者近 5 年第一作者发表高水平论文 |
| 接收入伍 | 数学、系统科学 | 博士研究生 | 数学、系统科学各研究方向（统计学、几何学、网络科学、运筹学优先、复杂系统理论） | 2 | 具有 1 年以上国外留学经历 |
| 军队文职人员 | 数学、系统科学 | 博士研究生 | 数学、系统科学各研究方向 | 4 | 双“211”学历要求（注:本科、博士均为 211 院校） |
| 博士后研究人员 | 数学、系统科学 | 博士研究生 | 数学、系统科学各研究方向 | 6 | |