2020 NCTS Optimization Day for Young Researchers

Department of Mathematics
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Jein-Shan Chen

Table 1: Schedule on December 14 (Monday), 2020. Place: M212, Mathematics Building

	Speaker	Title
09:20 10:00	Jan Harold Alcantara	Smooth nonconvex regularizers for sparse recovery problems and an efficient conjugate gradient algorithm
10:00 10:40	Szu-Chi Chung	Dimension reduction and clustering method for noisy high-dimensional images and application to Cryogenic Electron Microscopy
	Tea Break	
11:00 11:40	Chien-Hao Huang	A survey on Young inequality under Euclidean Jordan algebra
11:40 12:20	Chieu Thanh Nguyen	Construction of smoothing functions for nonsmooth function and its application
	Lunch Break	
13:40 14:20	Daniel Stanley Tan	Learning to semantically manipulate images
14:20 15:00	John Jethro Virtusio	Demystifying AI creativity
	Tea Break	
15:20 16:00	Chun-Han Wang	Frequency competition among airlines on coordinated airports network
16:00 16:40	Bernadette Louise Santos	A general smoothing approach for the smallest enclosing ball problem

Smooth Nonconvex Regularizers for Sparse Recovery Problems and an Efficient Conjugate Gradient Algorithm

Jan Harold Alcantara
Department of Mathematics
National Taiwan Normal University
Taipei 11677, Taiwan
E-mail: jan.alcantara@dlsu.edu.ph

Abstract. In this talk, we present a class of smooth nonconvex regularizers for sparse recovery problems which is inspired by a continuous reweighted technique. The objective function of the nonconvex regularized model possesses some nice properties including coercivity and Lipschitz continuity of its gradient, which makes the conjugate gradient (CG) algorithm a suitable and globally convergent approach. Using the CG algorithm along with a continuation method, we demonstrate via extensive numerical experiments desirable several advantages of our approach. In comparison with other popular solvers, our proposed model together with the CG algorithm is significantly more dominant in terms of speed, scalability, and accuracy. More importantly, our approach can handle difficult sparse recovery problems including those where only a few measurements are available and those where the signal to be recovered is not strictly sparse or is of high dynamic range.

Keywords. sparse recovery; nonconvex regularization; conjugate gradient algorithm

Dimension Reduction and Clustering Method for Noisy High-dimensional Images and Application to Cryogenic Electron Microscopy

Szu-Chi Chung
Institute of Statistical Science
Academia Sinica
Nankang 11529, Taiwan
E-mail: phonchi@stat.sinica.edu.tw

Abstract. With the recent advancement of GPU-accelerated computations and algorithms, cryo-EM has become a mainstream technique to solve 3D structures of macromolecules at near-atomic resolution. Since the outbreak of COVID-19 in January, a dynamic movie of 2019-nCoV Spike trimer structure derived from its various conformations was published in March. This further demonstrated that cryo-EM had been a powerful technique with high efficiency to provide crucial medical insight for developing vaccines. However, the data characteristics include strong noise, huge dimension, large sample size and high heterogeneity with unknown orientations have made analysis very challenging. In the literature, dimension reduction and clustering play an important role in overcoming the challenges above. The traditional methods utilized in the field, however, does not well suited for the scenario and they face bottleneck either in computation or performance. In this talk, I will first introduce the related background and principles of cryo-EM image processing. Second, I will discuss our proposed dimension reduction strategy called two-stage dimension reduction (2SDR) which alleviates the computation burden and improves performance over existing methods. Finally, a clustering method called DRMRA that combines robust clustering and multi-reference alignment will be introduced. Specifically, I will show how the algorithm can be accelerated using space-partition tree. Finally, I will discuss how the methods can be employed to improve the overall cryo-EM image processing workflow.

A Survey on Young Inequality under Euclidean Jordan Algebra

Chien-Hao Huang
General Education Center
Wenzao Ursuline University of Languages
Kaohsiung 80793, Taiwan
E-mail: 100300@mail.wzu.edu.tw

Abstract. Recently, some inequalities and trace inequalities associated with second-order cone are established. Most of them are very useful in optimization. In particular, in our recent work [1], we build up some trace versions of Young inequality in the SOC setting and indicate that the Young inequality does not hold in general. In this talk, we will give a survey on Young inequality under Euclidean Jordan algebra. By using spectral decomposition, we extend one trace version of Young inequality to the general setting of symmetric cone. In addition, we provide conditions under which the Young inequality holds in the SOC setting. Accordingly, one can construct counterexamples in general case.

References

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Construction of Smoothing Functions for Nonsmooth Function and Its Application

Chieu Thanh Nguyen
Department of Mathematics
National Taiwan Normal University
Taipei 11677, Taiwan
E-mail: thanhchieu90@gmail.com

Abstract. In this talk, we summary several methods to construct smoothing functions for nonsmooth function in the literature. Based on these methods, we construct smoothing functions for specific nonsmooth functions like l_0-norm, pinball function, MCP and SCAD penalty. Moreover, we also propose another way to construct smoothing functions for plus function from which we are able to establish smoothing functions for absolute value function, pinball function, and so on. Finally, we present several numerical simulations to indicate the feasibility and efficacy in replacing nonsmooth optimization problems with smooth optimization problems.

A General Smoothing Approach for the Smallest Enclosing Ball Problem

Bernadette Louise Santos
Department of Mathematics
National Taiwan Normal University
Taipei 11677, Taiwan
E-mail: bernadette.santos@dlsu.edu.ph

Abstract. We consider the problem of finding the ball with smallest radius that encloses a set of m balls in $\mathbb{R}^n$. This is known as the smallest enclosing ball problem which can be formulated as a non-differentiable convex programming problem. In this study, the problem is reformulated as an unconstrained convex optimization problem involving the plus function. A general framework of generating smoothing approximation of the plus function is used to prove convergence results. Results of preliminary numerical simulations are presented showing which kinds of smoothing functions perform best along with the smoothing BFGS algorithm.

References

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Learning to Semantically Manipulate Images

Daniel Stanley Tan
Department of Computer Science and Information Engineering
National Taiwan University of Science and Technology
Taipei 106335, Taiwan
E-mail: danieltan07@gmail.com

Abstract. Ever since the digital camera was invented, people have been manipulating images to influence people's perception of an image. While tools such as Photoshop allow anyone to manipulate their photos, creating convincing images requires a set of artistic expertise that few people have. Not to mention that even seemingly simple image manipulation tasks such as adding and removing objects may already be difficult and time consuming to do since we have to explicitly tune everything "just right" including shape, color, and lighting, for a human to perceive an image as realistic. Wouldn't it be nice to have an automatic tool that could perform these complex semantic manipulations such as changing hair color, gender, and age with just a click of a button? In this talk, I will present some of the recent breakthrough ideas inside tools, such as FaceApp, that take us a step towards this goal.

Demystifying AI reativity

John Jethro Virtusio
Department of Computer Science and Information Engineering
National Taiwan University of Science and Technology
Taipei 106335, Taiwan
E-mail: jetvirtusio@gmail.com

Abstract. Advancements in deep learning blurred the lines that separated creativity and mimicry. We've recently seen artificial intelligence generate works of art indistinguishable from the paintings of creative geniuses like Pablo Picasso, Vincent van Gogh, and Claude Monet. These advancements are shrouded in mystery and give the impression that maybe AI can be creative just like humans. In this presentation, I will pinpoint the events that allowed this to happen and answer the question, "What changed between now and before the deep learning era?". We will go through examples and simplify ideas that allowed the illusion of AI creativity. Specifically, we will discuss Neural Style Transfer and show how it represents images and artistic style. By the end of this presentation, the participants will have a good understanding of AI creativity, assuring them that artificial intelligence won't be replacing human painters/artists anytime soon.

Frequency Competition Among Airlines on Coordinated Airports Network

Chun-Han Wang
Department of Industrial Engineering and Engineering Management
National Tsing Hua University
Hsinchu 30013, Taiwan
E-mail: ga2006197730@yahoo.com.tw

Abstract. Frequency competition is critical for a full-service airline in gaining market share, and adopting a proper strategy can improve an airline's profits. In this study, we propose a new equilibrium programming model with flow balance to address frequency competition on airports network with time slot constraints. We first show that a pure-strategy Nash equilibrium may not always exist and thus forming a pure strategy profile in frequency competition among airlines may naturally lead to deviation from current frequency. Therefore, we formulate the problem as a programming model with a mixed-strategy Nash equilibrium. To reduce computational burden arising from the excessively large number of strategies, we propose a generation procedure to select representative strategies from the finite set of feasible strategies. To avoid shock arising from dramatic frequency changes everywhere over the network, airlines tend to fine tune frequency on few selected segments each time of adjustment. We propose a procedure to generate a computationally tractable amount of representative strategies from the finite set of feasible strategies to illustrate the mixed-strategy Nash equilibrium. Our empirical analysis shows example in which industry profitability is increased by as much as 7.89%. We then extend the model to formulate frequency competition among metal-neutral alliances. The results show that forming metal-neutral alliances can improve the total industry profits by 10.59%. In particular, a sensitivity analysis on the tolerance of flow imbalance demonstrates that deducting the potential costs due to the relaxation of flow balance between congested airports may earn additional total industry profits in frequency competition with real data.