Preface: Special Issue on Optimization Models and Algorithms in Artificial Intelligence

Ya-Xin Peng¹ · Shao-Yi Du² · Tie-Yong Zeng³

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Artificial intelligence (AI) and its applications have been a hot topic in recent years, while the optimization architecture is one of its key contents. In fact, typical AI models are often represented by minimizing or maximizing a certain objective/energy function. Therefore, an optimization model with a fast and robust algorithm is of great importance for AI.

Traditional mathematical optimization models are based on human knowledge or physical hypothesis and have been playing a vital role in AI. We call them model-driven methods. Two model-driven papers are presented in this special issue to deal with the restoration and registration problems. With the development of machine learning algorithms and computational resources, data-driven methods have been becoming more and more useful in AI, due to their flexibility and efficiency for large-scale data. There are two data-driven papers presented in this issue to solve the classification and data-generating problems. Nowadays, the combination of model and data-driven methods becomes one of the hottest topics in AI, since it has the advantages of both methods. We therefore introduce two papers using this methodology. These papers present the learned prior information into optimization models for medical tumor diagnosis and 3D reconstruction. For the theoretical part of optimization, two papers submitted to the regular issues are selected. They cover the areas of graphs and game theory.

This issue comprises of eight papers, exhibiting exploration and exploitation of optimization models and algorithms in AI by a variety of scholars from home and

✉ Ya-Xin Peng
yaxin.peng@shu.edu.cn

Shao-Yi Du
dushaoyi@xjtu.edu.cn

Tie-Yong Zeng
zeng@math.cuhk.edu.hk

¹ Department of Mathematics, School of Science, Shanghai University, Shanghai 200444, China

² Institute of Artificial Intelligence and Robotics, Xi'an Jiaotong University, Xi'an 710049, China

³ Department of Mathematics, The Chinese University of Hong Kong, Hong Kong, China

abroad. Among these papers, three are invited papers authored by three famous experts, Yun-Mei Chen, Raymond Honfu Chan, and Yan-Qin Bai, together with their respective collaborators. Professors Chen, Chan, and Bai have made considerable contribution on optimization models and algorithms in AI. They have refined and proposed many computational methods, theories and solvers to computer vision, medical AI, and financial areas, such as fast bundle level, extra accelerated proximal gradient network, iterative Toeplitz solvers and interior-point methods. To demonstrate the integrity of the medical AI, this issue includes a paper submitted to the regular issue, Longitudinal image analysis via path regression on the image manifold, co-authored by medical AI specialist Professor Ding-Gang Shen. Therefore, the scope of medical AI in this issue includes medical image classification, segmentation, restoration, registration and longitudinal trend prediction. This issue is an exhibition of the influence and inspirations from these four experts. All papers in this issue are summarized as follows.

Wen-Ming Wu, Xiao-Hui Yang, Yun-Mei Chen, Juan Zhang, Dan Long, Li-Jun Yang and Chen-Xi Tian create a layer-wise pre-training low-rank nonnegative matrix factorization optimization model and introduce the deep learned feature representation to their classification framework. Moreover, the proposed optimization model is implemented by alternating direction method of multipliers (ADMM), and the convergence analysis is also provided. Experiments on the public and actual clinical datasets show that the classification accuracy, specificity and sensitivity achieve the clinical acceptance level.

Raymond Honfu Chan and Hai-Xia Liang investigate the truncated fractional-order total variation model for image restoration. To improve the reconstruction accuracy, the authors propose a truncation technique when the discrete fractional-order derivative operator is generated and then propose a truncated fractional-order total variation model for image restoration. The ADMM based algorithms are generated and the convergence results are briefly discussed.

Qian-Qian Gao, Yan-Qin Bai and Ya-Ru Zhan suggest a quadratic kernel-free least square twin support vector machine (QLSTSVM) for binary classification problems. The proposed optimization model (QLSTSVM) has the advantage of no need to select the kernel function and related parameters for nonlinear classification problems, which is implemented by ADMM. Furthermore, the Karush–Kuhn–Tucker conditions are also used to lower computational time.

Shi-Hui Ying, Xiao-Fang Zhang, Ya-Xin Peng and Ding-Gang Shen propose a novel path regression on the image manifold by the diffeomorphism group representation instead of geodesic regression, since a large deformation is hard to be diffeomorphic. This paper first converts the longitudinal medical image regression problem into an optimization model by decomposing a large deformation to several small deformations and then approximating the small deformations by the linearization of manifold. The suggested optimization model is solved using ADMM and the linearization of diffeomorphism group, which keeps the geometric structure in small deformation and avoids the complexity of the geodesic computation. The results show that the proposed model and algorithm perform accurately for the infant magnetic resonance image analysis.

Xin Wang, Shuai Xu, Zhen Ye, Chao-Zheng Zhou and Jing Qin propose a prior information-based variational model for automatic hip joint segmentation and 3D reconstruction. They modify the segmentation and 3D reconstruction problems to find

the optimal solution of evolution equations. To solve the topology problem, the optimal edge of the model is represented as its level set. Then, they obtain prior features by automatic sample selection and a discriminative function by training these selected samples, and integrate this prior information into the variational level set model.

Yi-Ying Zhang, Chao-Min Shen, Hao Feng, Preston Thomas Fletcher and Gui-Xu Zhang use generative adversarial networks (GANs) with joint distribution moment matching (JDMM) to generate images. This topic is significant as data generating is a way for solving the problem of lacking labeled data in few-shot learning. Their JDMM-GAN matches the joint distribution based on the maximum mean discrepancy, which minimizes the differences of both the marginal and conditional distributions. The learning procedure is iteratively conducted by the stochastic gradient descent and back-propagation.

Zhi-Hong He and Mei Lu explain the super-edge-connectivity and zeroth-order Randić index. They present two sufficient conditions for graphs and triangle-free graphs to be super-edge-connected in terms of the zeroth-order Randić index, respectively.

Zhe Yang and Qing-Bin Gong prove the existence of weakly cooperative equilibria for infinite-leader-infinite-follower games. They first generalize Yang and Ju's (J Glob Optim 65:563–573, 2016) result in Hausdorff topological vector spaces, and then present the model of leader–follower games with infinitely many leaders and followers. Finally, they provide a proof of the existence result.

We hope that this issue can capture readers' attention on the optimization models and algorithms in AI, especially in the combination of model-driven and data-driven methods.

All papers in this special issue have been peer-reviewed to meet the high standard of the journal. We wish to express our gratitude to all authors for their significant contribution to this issue. Their quick response and timely revisions are highly appreciated. We acknowledge all reviewers for their thoughtful comments as well.

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