

Objective-Domain Dual Decomposition: An Effective Approach to Optimizing Partially Differentiable Objective Functions

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(for The Computational Intelligence Society (CIS) Chapter of IEEE Xiamen Section,
Xiamen University, Xiamen, China, 25 Sept 2020)

Report: On 25 Sept 2020, at 3:00-4:00 pm, Yiu-ming delivered a DL talk for The Computational Intelligence Society (CIS) Chapter of IEEE Xiamen Section, at Xiamen University, Xiamen, China, chaired by Professor Min Jiang. Yiu-ming Cheung proposed a dual-decomposition-based approach to solve the optimization problems in which either part of the objective function is differentiable while the rest is nondifferentiable or the objective function is differentiable in only part of the domain. A total of 208 IEEE members or non-members participated in the talk.

Abstract: There is a class of optimization problems in which either part of the objective function is differentiable while the rest is nondifferentiable or the objective function is differentiable in only part of the domain. Accordingly, Prof. Cheung proposes a dual-decomposition-based approach that includes both objective decomposition and domain decomposition. In the former, the original objective function is decomposed into several relatively simple subobjectives to isolate the nondifferentiable part of the objective function, and the problem is consequently formulated as a multiobjective optimization problem (MOP). In the latter decomposition, he decomposes the domain into two subdomains, that is, the differentiable and nondifferentiable domains, to isolate the nondifferentiable domain of the nondifferentiable subobjective. Subsequently, the problem can be optimized with different schemes in the different subdomains. Prof. Cheung proposes a population-based optimization algorithm, called the simulated water-stream algorithm (SWA), for solving this MOP. The SWA is inspired by the natural phenomenon of water streams moving toward a basin, which is analogous to the process of searching for the minimal solutions of an optimization problem. The proposed SWA combines the deterministic search and heuristic search in a single framework. Experiments show that the SWA yields promising results compared with its existing counterparts.

Partial Differentiable Problems

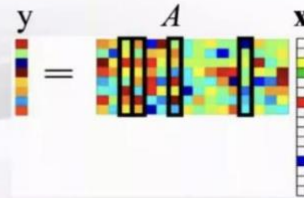
- ◆ There is at least one objective function is non-differentiable;
- ◆ Portion of objective functions or part of one objective function is differentiable.

☰ Sparse regularization

$$\min_x F(x) = \|Y - Ax\|_2^2 + \lambda \|x\|_p$$

$\|x\|_p$ is the ℓ_p -norm of x and $p \geq 0$

$F(x)$ is non-differentiable at $x=0$ as $p \leq 1$

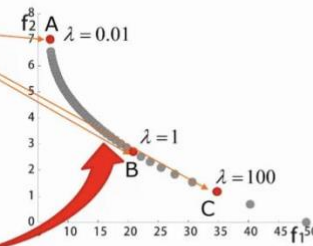


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An Example of Objective Decomposition

$$F(x) = \|Y - Ax\|_2^2 + \lambda \|x\|_1$$

$$\begin{cases} f_1(x) = \|Y - Ax\|_2^2 \\ f_2(x) = \|x\|_1 \end{cases}$$



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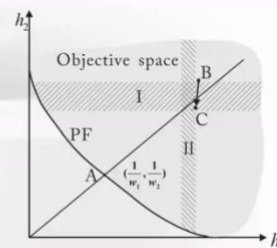
How to obtain $E(h, D)$

- By the Tchebycheff approach, Problem (c) can be solved by the following problem

$$\min_{x \in D} g(x|w) = \min_{x \in D} \max_{1 \leq i \leq m} \{w_i h_i(x)\} \quad (d)$$












































































































































➤ where $w = (w_1, \dots, w_m)^T$ is a weight vector

- (1) For any $\bar{x} \in E(h, D)$ of problem (c), there is at least one weight vector w such that \bar{x} is the optimal solution of problem (d).
- (2) Intersection A is one weak Pareto optimal solution of problem (c) with $w = (w_1, w_2)^T$



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Professor Yiu-ming Cheung during his talk

 江敏-厦门大学人工智能系 (主持人)	 	 洪云森	 
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 曾万康	 	 雷振风	 
 陈锦昌	 	 李根硕	 
 吴海	 	 刘畅	 
 吴旭	 	 刘佳嘉	 
 悟袁	 	 裴玉龙	 
 谢苾	 	 齐琦	 
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 叶佳	 	 唐浪	 
 叶晓毅	 	 童逸琦	 
 一如既往的朋朋	 	 汪泽丰	 
 英雄好汉	 	 王成济	 
		 王志豪	 
		 文斌	 

Participant list

Professor Yiu-ming Cheung

Brief Resume



Yiu-ming Cheung is a Full Professor of Department of Computer Science and an Associate Director of Institute of Computational and Theoretical Studies at Hong Kong Baptist University (HKBU). He received PhD degree from Department of Computer Science and Engineering at The Chinese University of Hong Kong in 2000, and then joined the Department of Computer Science at HKBU in 2001. He is an IEEE Fellow, IET/IEE Fellow, British Computer Society (BCS) Fellow, Fellow of the Royal Society of Arts (RSA), and Distinguished Fellow of International Engineering and Technology Institute, Hong Kong (IETI).

His research interests include Artificial Intelligence, Intelligent Visual Computing, Pattern Recognition, Data Mining, Watermarking, and Optimization. He has published over 250 articles in the high-quality conferences and journals, including TPAMI, TNNLS, TIFS, TIP, TKDE, IEEE Transactions on Cybernetics, CVPR, IJCAI, AAAI, and so on. His two co-authored papers have been selected as ESI Highly Cited Papers (i.e. listed in Top 1% globally in the corresponding discipline). Further, his work on multi-modal optimization won the championship in the competition of Multi-Niche Optimization held in CEC'2015 --- a flagship international conference on Evolutionary Computation. Moreover, he has been granted one Chinese patent and two US patents. In particular, selected from 1000 new inventions and products of 700+ competition teams from 40 countries, he was awarded two most prestigious prizes: (1) the Gold Medal with Distinction (i.e. the highest grade in Gold Medals) and (2) Swiss Automobile Club Prize, in the 45th International Exhibition of Invention, Geneva, Switzerland, on March 29-April 2, 2017, in recognition of his innovative work. Also, he was the Gold Award Winner of Hong Kong Innovative Invention Award in the Seventh Hong Kong Innovative Technologies Achievement Award 2017. In addition, he won the Gold Medal with Congratulations of Jury (i.e. the highest grade in Gold Medals) and the Award of Excellence from Romania, respectively, at the 46th International Exhibition of Inventions of Geneva 2018 with his invention "Lip-password: Double Security System for Identity Authentication". Prof. Cheung is the recipient of an IEEE Distinguished Lecturer (2020-2022), 2011 Best Research Award in Department of Computer Science, HKBU, the recipient of Best Paper

Awards in SEAL'2017, ISICA'2017, ICNC-FSKD'2014, and IEEE IWDVT'2005, respectively, the recipient of Best Student Paper Award in ISMIS'2018, and the recipient of 2017 IETI Annual Scientific Award. He has been recognized as the recipient of 2017-2019 Albert Nelson Marquis Lifetime Achievement Award.

He is the Founding Chairman of IEEE (Hong Kong) Computational Intelligence Chapter and the Chair of Technical Committee on Intelligent Informatics (TCII) of IEEE Computer Society. He has served in various capacities (e.g., Organizing Committee Chair, Program Committee Chair, Program Committee Area Chair, and Financial Chair) at several top-tier international conferences, including IJCAI'2021, ICPR'2020, ICDM'2017 & 2018, WCCI'2016, WI-IAT'2012, ICDM'2006 & WI-IAT'2006, to name a few. Currently, he is the Associate Editor of several prestigious journals, including IEEE Transactions on Neural Networks and Learning Systems, IEEE Transactions on Cybernetics, Pattern Recognition, Knowledge and Information Systems (KAIS), and Neurocomputing, as well as the Guest Editor in several international journals.