AFRL-AFOSR-VA-TR-2019-0346

Mechanism Design for Complex Systems: A Black-box Model Approach

Panagote Pardalos
UNIVERSITY OF FLORIDA

10/04/2019
Final Report

Air Force Research Laboratory
AF Office Of Scientific Research (AFOSR)/ RTA2
Arlington, Virginia 22203
Air Force Materiel Command

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
11-11-2019	Final Performance	30 Sep 2015 to 29 Sep 2019

4. TITLE AND SUBTITLE
Mechanism Design for Complex Systems: A Black-box Model Approach

5a. CONTRACT NUMBER

5b. GRANT NUMBER
FA9550-15-1-0504

5c. PROGRAM ELEMENT NUMBER
61102F

6. AUTHOR(S)
Panagote Pardalos, Alfredo Garcia

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
UNIVERSITY OF FLORIDA
207 GRINTER HALL
GAINESVILLE, FL 32611-5500 US

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
AF Office of Scientific Research
875 N. Randolph St. Room 3112
Arlington, VA 22203

10. SPONSOR/MONITOR'S ACRONYM(S)
AFRL/AFOSR RTA2

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
AFRL-AFOSR-VA-TR-2019-0346

12. DISTRIBUTION/AVAILABILITY STATEMENT
A DISTRIBUTION UNLIMITED: PB Public Release

13. SUPPLEMENTARY NOTES

14. ABSTRACT
In this project we study solution methods for distributed optimization problems over a multi-agent network, where each agent can only partially evaluate the objective function, and it is allowed to exchange messages with its immediate neighbors. Differently from all existing works on distributed optimization, our focus is given to optimizing a class of difficult non-convex problems, and under the challenging setting where each agent can only access the zeroth-order information (i.e., the functional values) of its local functions (this is also often referred to as black-box model).
We consider two generic settings: in the first, we assume agents in the network truthfully exchange information with neighbors. In the second setting, we relax this assumption thus turning the problem into a mechanism design problem requiring the design of incentives for truthful information reporting.

15. SUBJECT TERMS
Black-box Model Approach, Complex Systems, Mechanism Design

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			FAHROO, FARIBA
Unclassified	Unclassified	Unclassified	UU		19b. TELEPHONE NUMBER *(Include area code)* 703-696-8429

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

Final Report: Mechanism Design for Complex Systems: A Black-box Model Approach

PI: Alfredo Garcia (email: alfredo.garcia@ufl.edu)
Co-PI: Mingyi Hong (email: mingyi@iastate.edu)

Agency: **Air Force Office of Scientific Research (AFOSR)**

Program: **Discrete Mathematics and Optimization**

Grant: **15RT0767**

Reporting Period: **September 30, 2016 - September 30, 2019**

1 Introduction

This is the final report on the AFOSR project, "Mechanism Design for Complex Systems: A Black-box Model Approach", which was carried out at by A. Garcia (currently at Texas A&M University) and Mingyi Hong (currently at IU. of Minnesota). The present final report covers the period September 30, 2016 to September 29, 2019.

1.1 Summary of Research Activities

In this project we study solution methods for distributed optimization problems over a multi-agent network, where each agent can only partially evaluate the objective function, and it is allowed to exchange messages with its immediate neighbors. Differently from all existing works on distributed optimization, our focus is given to optimizing a class of difficult non-convex problems, and under the challenging setting where each agent can only access the zeroth-order information (i.e., the functional values) of its local functions (this is also often referred to as black-box model). We consider two generic settings: in the first, we assume agents in the network truthfully exchange information with neighbors. In the second setting, we relax this assumption thus turning the problem into a mechanism design problem requiring the design of incentives for truthful information reporting.

2 Products

In this section, we list the main products generated by this project.

1. "Zeroth Order Nonconvex Multi-Agent Optimization over Networks" (2019) D. Hajinezhad, M. Hong and A. Garcia, **IEEE Transactions on Automatic Control**, Vol. 64 No. 10, pp. 3995-4010

2. "Swarming for Faster Convergence in Stochastic Optimization" (2018) S. Pu and A. Garcia, **SIAM Journal on Control and Optimization**, Vol. 56 No. 4, pp. 2997-3020.

3. W.-C. Liao, M. Hong, H. Farmanbar, and Z.-Q. Luo, "A Distributed Semi-Asynchronous Algorithm for Network Traffic Engineering", **IEEE Transactions on Signal and Information Processing over Networks**, Volume: 4 , Issue: 3 , Sept. 2018)

4. "A Flocking-based Approach for Distributed Stochastic Optimization" (2017) S. Pu and A. Garcia, **Operations Research**, Vol 6, pp. 267-281

5. "Prox-PDA: The Proximal Primal-Dual Algorithm for Fast Distributed Nonconvex Optimization and Learning Over Networks", M. Hong, D. Hajinezhad, M.-M. Zhao, Proc. **International Conference on Machine Learning** (ICML) 2017

6. D. Hajinezhad, M. Hong, T. Zhao, and Z. Wang, "NESTT: A nonconvex primal-dual splitting method for distributed and stochastic optimization," in **Proceedings of Neural Information Processing** (NIPS), 2016

7. P. Shi, A. Garcia and Z. Lin "Noise Reduction by Swarming in Social Foraging", **IEEE Transactions on Automatic Control**, (2016) Vol. 61, No. 12 pp. 4007-4013.

3 Students Funded

This project has partially supported the following graduate students

1. Pu Sun, graduated in 2017 (PhD).

2. Davood Hajinezhad, graduated in 2018 (PhD).

3. Luochao Wang, 2019 (M.Sc.)

4. Songtao Lu, graduated in 2019 (PhD)

4 Other Activities Supported

This project has supported the following activities

- Travel of both PIs to attend the annual review meetings held at Arlington VA.
- Travel of both PIs and students to present research funded by this project at INFORMS (2016, 2018) and IEEE CDC (2017, 2018), ISMP (2018), DIMACS Workshop on Distributed Optimization, Information Processing, and Learning, New Brunswick, NJ, 2017
- Summer support for both PIs.