Accepted Manuscript

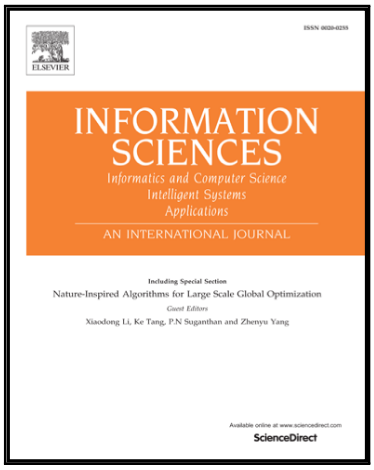
A general framework for population-based distributed optimization over networks

Wu Ai, Weisheng Chen, Jin Xie

PII: S0020-0255(16)30948-3
DOI: 10.1016/j.ins.2017.08.010
Reference: INS 13014

To appear in: *Information Sciences*

Received date: 18 September 2016
Revised date: 10 July 2017
Accepted date: 2 August 2017



Please cite this article as: Wu Ai, Weisheng Chen, Jin Xie, A general framework for population-based distributed optimization over networks, *Information Sciences* (2017), doi: 10.1016/j.ins.2017.08.010

A general framework for population-based distributed optimization over networks☆

Wu Ai[a,b,c], Weisheng Chen[d,*], Jin Xie[a]

[a]School of Mathematics and Statistics, Xidian University, Xi'an 710071, PR China
[b]College of Science, Guilin University of Technology, Guilin 541004, PR China
[c]Guangxi Key Laboratory of Spatial Information and Geomatics, Guilin 541004, PR China
[d]School of Aerospace Science and Technology, Xidian University, Xi'an 710071, PR China

Abstract

This paper presents a population-based solution for the distributed optimization problem where the overall objective function is defined as an average of local cost functions corresponding to the nodes of a network. Populations are introduced for the nodes to cooperatively find the global optimum of the overall objective function. The main challenge is that each population cannot know the overall objective function and thus cannot directly evaluate the quality of their individuals in each iteration. To overcome this difficulty, we introduce consensus methods to design a message-passing protocol under which the local estimates can converge to the same value. We present a general framework that consists of consensus search, consensus evaluation, population evolution and local stopping steps. Compared with mathematical methods, this framework solves in-network distributed optimization problems without requiring a convexity assumption on the objective functions. The standard PSO and one of its variants, called MCO, are introduced for testing and comparison. Two simulated examples under different network topologies illustrate the feasibility of our approach.

Keywords: Metaheuristics, particle swarm optimization (PSO), distributed optimization, average consensus, fitness evaluation

1. Introduction

In this paper, we focus on the multi-agent optimization problem in an n-node network where each node associates a scalar local cost function $f_i(x)$ with $f_i : \mathbb{R}^D \to \mathbb{R}$ that is known by this node only. The vector $x \in \mathbb{R}^D$ represents a global decision vector that the nodes are collectively trying to decide on. The whole network objective function is defined as an average of all f_i's. The global variable x^* can be obtained by solving the following problem in a distributed fashion.

$$x^* = \arg\min_{x\in\mathbb{R}^D} \frac{1}{n}\sum_{i=1}^{n} f_i(x). \tag{1}$$

Here, the word 'distributed' means that each node utilizes the information from their local neighbors, and no node can know the global information of the network, such as all f_i's. Problem (1) comes up in many applications, such as parallel computing [47, 46], parameter estimation [41], distributed learning [1, 2], resource allocation [34, 61] and data fusion in wireless sensor networks (WSNs) [38, 53, 31]. For practical use, there is a desire to develop distributed

☆This work was supported in part by the National Natural Science Foundation of China (Nos. 61673308, 61673014, 11661028 and 61503292), the Natural Science Foundation of Guangxi (Nos. 2014GXNSFBA118023 and 2015GXNSFBA139259) and the Director Foundation of Guangxi Key Laboratory of Spatial Information and Geomatics (16-380-25-20).

*Corresponding author
Email addresses: aiwu818@gmail.com (Wu Ai), wshchen@126.com (Weisheng Chen), Static_6417@163.com (Jin Xie)