My Title

My Name

School of Electrical & Electronic Engineering

A thesis submitted to the Nanyang Technological University
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy

2018

Statement of Originality

I hereby certify that the intellectual content of this thesis is the product of my original research work and has not been submitted for a higher degree to any other University or Institution.

. . . .

Date   My Name

Acknowledgements

I wish to express my greatest gratitude to my advisor.

"If I had one hour to save the world, I would spend 55 minutes defining the problem and only five minutes finding the solution."

—Einstein, Albert

To my dear family

Abstract

My abstracts

Contents

List of Figures

Symbols and Acronyms

Symbols

$\mathcal{R}^n$	the n-dimensional Euclidean space
$\mathcal{H}$	the Euclidean space
$\|\cdot\|$	the 2-norm of a vector or matrix in Euclidean space
$\|\cdot\|_G$	the induced norm of a vector in G-space
$\|\cdot\|_E$	the induced norm of a vector or matrix in probabilistic space
$\odot$	the Hadamard (component-wise) product
$\otimes$	the Kronecker product
$\langle\cdot,\cdot\rangle$	the inner product of two vectors
$\circ$	the composition of functions
∇f	the gradient vector
$\mathcal{C}^k$	the function with continuous partial derivatives up to k orders
$x_{i,k}$	the i-th component of a vector x at time k
$\bar{x}$	the vector with the average of all components of x as each element
$\mathbf{1}$	all-ones column vector with proper dimension
$\mathcal{C}$	the average space, i.e., $span\{\mathbf{1}\}$
$\mathcal{C}^{\perp}$	the disagreement space, i.e., $span^{\perp}\{\mathbf{1}\}$
$\Pi_{\parallel}$	the projection matrix to the average space $\mathcal{C}$
$\Pi_{\perp}$	the projection matrix to the disagreement space $\mathcal{C}^{\perp}$
$O(\cdot)$	order of magnitude or ergodic convergence rate (running average)
$o(\cdot)$	non-ergodic convergence rate
$\mathcal{N}_i$	the index set of the neighbors of agent i

Acronyms

DOP	Distributed Optimization Problem
EDOP	Equivalent Distributed Optimization Problem
SDOP	Stochastic Distributed Optimization Problem
OEP	Optimal Exchange Problem
OCP	Optimal Consensus Problem
DOCP	Dynamic Optimal Consensus Problem
AugDGM	Augmented Distributed Gradient Methods
AsynDGM	Asynchronous Distributed Gradient Methods
D-ESC	Distributed Extremum Seeking Control
D-SPA	Distributed Simultaneous Perturbation Approach
D-FBBS	Distributed Forward-Backward Bregman Splitting
ADMM	Alternating Direction Method of Multipliers
DSM	Distributed (Sub)gradient Method
GAS	Globally Asymptotically Stable
UGAS	Uniformly Globally Asymptotically Stable
SPAS	Semi-globally Practically Asymptotically Stable
USPAS	Uniformly Semi-globally Practically Asymptotically Stable
HoS	Heterogeneity of Stepsize
FPR	Fixed Point Residual
OBE	Objective Error
i.i.d.	independent and identically distributed
a.s.	almost sure convergence of a random sequence

Chapter 1

Introduction

1.1 Scope and Overview

My overview 1.1.

FIGURE 1.1: An illustration.

1.2 Major Contributions

Our main contributions can be stated as follows:

- *First part*: My first contributions, several lines
- *Second*: Second contributions, several lines
- *Third name*: Third contributions, several lines

1.3 Outline of the Thesis

Chapter 1 introduces ...

Chapter 2 reviews

More chapters ....

....

Chapter 2

Literature Review

2.1 part 1

contents: cite [1].

2.2 part 2

contents: cite [2]

Chapter 3

Chapter3 name

3.1 section1

See Fig. 3.1

Figure 3.1: Another illustration.

$$F(\theta) = \sum_{i=1}^{m} f_i(\theta) \tag{DOP}$$

3.2 section2

Appendix A

Proofs for Part I

A.1 Proof of Lemma

$$\psi^{av}(\theta) = \frac{1}{T}\int_0^T [\psi(\theta + \mu(\tau)) + C] \otimes \frac{\mu(\tau)}{a} d\tau$$

A.2 Proof of another Lemma

$$\begin{aligned} \gamma_1(\|x\|) \leq W(t,x) \leq \gamma_2(\|x\|) \\ \frac{\partial W}{\partial t} + \frac{\partial W}{\partial x}\phi(t,x,0) \leq -\gamma_3(\|x\|) \end{aligned} \tag{A.1}$$

Author's Publications

Journal Articles

- **My name** and My colleague, "A Great System," *Nature*.

Conference Proceedings

- **My name**, My colleague 1, My colleague 3 and My colleague 3, "Greater System," in *Conference of Vision, 2018*.

Bibliography

[1] Heinz H Bauschke and Patrick L Combettes. *Convex analysis and monotone operator theory in Hilbert spaces.* Springer Science & Business Media, 2011.

[2] J. B. Rawlings and B. T. Stewart. Coordinating multiple optimization-based controllers: New opportunities and challenges. *Journal of Process Control*, 18: 839–845, 2008.