Xi Wang

PERSONAL DETAILS

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EDUCATIONAL BACKGROUND

University of New South Wales 2023-Now
Postdoctoral Research Fellow
Supervisor: Professor Victor Solo

Australian Centre for Robotics, University of Sydney 2022-2023
Visiting Ph.D. student
Supervisor: Associate Professor Guodong Shi

Academy of Mathematics and Systems Science, Chinese Academy of Sciences 2018-2024
Ph.D. in Operational Research and Cybernetics
Supervisor: Professor Yiguang Hong

University of Chinese Academy of Sciences 2014-2018
B.Sc. in Mathematics and Applied Mathematics

RESEARCH INTEREST

Riemannian Optimization
Riemannian Stochastic Numerical Analysis
Online Optimization
Stochastic Control on Lie Groups

PUBLICATIONS

Published or Accepted:

- **Xi Wang**, Zhipeng Tu, Yiguang Hong, Yingyi Wu, and Guodong Shi*. "Online Optimization over Riemannian Manifolds." Journal of Machine Learning Research 24, no. 84 (2023): 1-67.

  Abstract Online optimization has witnessed a massive surge of research attention in recent years. In this paper, we propose online gradient descent and online bandit algorithms over Riemannian manifolds in full information and bandit feedback settings respectively, for both geodesically convex and strongly geodesically convex functions. We establish a series of upper bounds on the regrets for the proposed algorithms over Hadamard manifolds. We also find a universal lower bound for achievable regret on Hadamard manifolds. Our analysis shows how time horizon, dimension, and sectional curvature bounds have impact on the regret bounds. When the manifold permits positive sectional curvature, we prove similar regret bound can be established by handling non-constrictive project maps. In addition, numerical studies on problems defined on symmetric positive definite matrix manifold, hyperbolic spaces, and Grassmann manifolds are provided to validate our theoretical findings, using synthetic and real-world data.

- **Xi Wang**, Zhipeng Tu, Yiguang Hong*, Yingyi Wu, and Guodong Shi. "No-regret Online Learning over Riemannian Manifolds." Advances in Neural Information Processing Systems 34 (2021): 28323-28335.

Abstract We consider online optimization over Riemannian manifolds, where a learner attempts to minimize a sequence of time-varying loss functions defined on Riemannian manifolds. Though many Euclidean online convex optimization algorithms have been proven useful in a wide range of areas, less attention has been paid to their Riemannian counterparts. In this paper, we study Riemannian online gradient descent (R-OGD) on Hadamard manifolds for both geodesically convex and strongly geodesically convex loss functions, and Riemannian bandit algorithm (R-BAN) on Hadamard homogeneous manifolds for geodesically convex functions. We establish upper bounds on the regrets of the problem with respect to time horizon, manifold curvature, and manifold dimension. We also find a universal lower bound for the achievable regret by constructing an online convex optimization problem on Hadamard manifolds. All the obtained regret bounds match the corresponding results are provided in Euclidean spaces. Finally, some numerical experiments validate our theoretical results.

- **Xi Wang**, Deming Yuan*, Yiguang Hong, Zihao Hu, Lei Wang and Guodong Shi. "Riemannian Online Optimistic Algorithms with Dynamic Regret". IEEE Transactions on Automatic Control: 1–16. Accepted for publication.

  Abstract In this paper, we consider Riemannian online convex optimization with dynamic regret, which involves minimizing the cumulative loss difference between a learner's decisions and a sequence of adaptive decisions across dynamic environments over time on Riemannian manifolds. First, we propose Riemannian Online Optimistic Gradient Descent (R-OOGD), which extends the classical optimistic algorithms to Riemannian manifolds, requiring one gradient inquiry per round. We then propose Riemannian Adaptive Online Optimistic Gradient Descent (R-AOOGD) by incorporating the meta-expert framework into R-OOGD. We analyze the dynamic regret of R-OOGD and R-AOOGD in terms of the regularity of the sequence of cost functions and comparators. The dynamic regret bound matches the results in Euclidean space and with a scale adjustment of $\mathcal{O}(\frac{1+\kappa D^2}{\sqrt{1-KD^2}})$ related to the sectional curvature lower bound κ, sectional curvature upper bound K and feasible set diameter D. Finally, we provide numerical experiments to illustrate the performance of the proposed algorithms.

- Jishu Zhao, **Xi Wang**, and Jinlong Lei*. "Distributed Riemannian Stochastic Gradient Tracking Algorithm on the Stiefel Manifold." Submitted to Automatica, provisionally accepted.

- Zhipeng Tu, **Xi Wang**, Yiguang Hong, Lei Wang, Deming Yuan, and Guodong Shi*. "Distributed Online Convex Optimization with Compressed Communication." Advances in Neural Information Processing Systems 35 (2022): 34492-34504.

- Zihao Hu, Guanghui Wang, **Xi Wang**, Andre Wibisono, Jacob D. Abernethy, and Molei Tao. "Extragradient Type Methods for Riemannian Variational Inequality Problems." International Conference on Artificial Intelligence and Statistics 27 (2024): 2080-2088.

Under Review:

- **Xi Wang** and Guodong Shi. "Foundations and Trends in Riemannian Online Learning.", submitted to Foundations and Trends® in Machine Learning.

- **Xi Wang** and Victor Solo. "Geometry-preserving Numerical Scheme for Riemannian Stochastic Differential Equations." Submitted to Automatica, Under Review.

- **Xi Wang** and Victor Solo. "Tangent Space Parametrization for Stochastic Differential Equations on SO(n)." Submitted to IEEE Control Systems Letters, Under Review.

- **Xi Wang**, Xiaoyi Wang and Victor Solo*. "Stochastic Kinematic Optimal Control on SO(3)."

INVITED TALKS

Presenter, the 36th conference on Neural Information Processing Systems 2022
Paper: Distributed Online Convex Optimization with Compressed Communication

Presenter, the 35th conference on Neural Information Processing Systems 2021
Paper: No-regret Online Learning over Riemannian Manifolds

Presenter, the 40th Chinese Control Conference 2021
Poster: A Gradient-based Online Optimization Method on Riemannian Manifold

Presenter, 2020 China Automation Congress 2020
Poster: Learning Algorithm Design based on Manifold Optimization

TEACHING EXPERIENCE

Casual Academic Feb. 2023 – Jun. 2023

School of Aerospace, Mechanical and Mechatronic, University of Sydney

AMME3500 System Dynamics and Control (Coordinator: Associate Professor Guodong Shi)

Teaching Assistant Sep. 2020 – Jan. 2021

School of Mathematical Sciences, University of Chinese Academy of Sciences

B0111002Y Complex Analysis (Coordinator: Professor Shaoji Feng)