Workshop on Vector Optimization, Active Learning, Design of Experiments, Game Theory, and Their Applications

5 March 2024, 9:00-12:00

Location: Electrical and Electronic Engineering Building, Room: EE-01, Bilkent University

Organizing Committee:
Assoc. Prof. Cem Tekin, Bilkent University
Asst. Prof. Çağın Ararat, Bilkent University

9:00-9:10 Opening remarks

9:10-9:30 **Talk title:** Vector Optimization via Gaussian Process Bandits
Presenter: Onat Korkmaz, Bilkent University

9:30-9:50 **Talk Title:** Adaptive Pure Exploration in Vector Bandits
Presenter: Efe Mert Karagözlü, Bilkent University

9:50-10:10 **Talk Title:** A Framework for Vector Optimization with Active Learning
Presenter: Yaşar Cahit Yıldırım, Bilkent University

10:10-10:30 Coffee break

10:30-10:50 **Talk Title:** Taming the Wild West of AI: Game Theory for Predictable AI Interactions
Presenter: Asst. Prof. Muhammed Ömer Sayın, Bilkent University

10:50-11:10 **Talk Title:** Inverse Decision Modeling: Learning Interpretable Representations of Behavior
Presenter: Alihan Hüyük, University of Cambridge

11:10-11:30 **Talk Title:** Convergence Analysis of a Norm Minimization-Based Convex Vector Optimization Algorithm
Presenter: Asst. Prof. Muhammad Umer, National University of Science and Technology, Pakistan

11:30-11:50 **Talk Title:** Robust Bayesian Satisficing
Presenter: Artun Saday, Bilkent University

11:50-12:00 Closing remarks

Program Details

9:10-9:30

Title: Vector Optimization via Gaussian Process Bandits

Presenter: Onat Korkmaz, Bilkent University

Abstract: This work discusses the implementation of vector optimization via Gaussian process bandits. The motivations are the advantages of vector-objective optimization in real-world scenarios, where traditional methods fall short in handling objective preferences effectively. We will showcase a vector optimization algorithm that uses Gaussian process bandits for vector optimization, allowing for more efficient sampling while also incorporating objective preferences through ordering cones. We will go on to discuss the theoretical guarantees and empirical tests on real-world and synthetic datasets, presenting a significant advancement in sequential vector optimization.

Bio: İlter is an MS student in the Department of Electrical and Electronics Engineering at Bilkent University. His research interests are multi-objective optimization, Bayesian optimization, Gaussian processes, and vector optimization.

9:30-9:50

Title: Adaptive Pure Exploration in Vector Bandits

Presenter: Efe Mert Karagözlü, Bilkent University

Abstract: We study pure exploration in bandit problems with vector-valued rewards, where the goal is to (approximately) identify the Pareto set of arms given incomplete preferences induced by a polyhedral convex cone. We address the open problem of designing sample-efficient learning algorithms for such problems. We propose Pareto Vector Bandits (PaVeBa), an adaptive elimination algorithm that nearly matches the gap-dependent and worst-case lower bounds on the sample complexity of (ϵ, δ)-PAC Pareto set identification. Finally, we provide an in-depth numerical investigation of PaVeBa and its heuristic variants by comparing them with the state-of-the-art multi-objective and vector optimization algorithms on several real-world datasets with conflicting objectives.

Bio: Efe Mert Karagözlü is a senior Bachelor's student at Electrical and Electronics Engineering, Bilkent University. His research at CYBORG Bilkent aims to generalize multi-objective black-box optimization using arbitrary vector orderings through polyhedral cones.

9:50-10:10

Title: A Framework for Vector Optimization with Active Learning

Presenter: Yaşar Cahit Yıldırım, Bilkent University

Abstract: In the optimization literature, multi-objective optimization stands as a pivotal approach that can simultaneously address multiple conflicting objectives. Vector Bayesian optimization is an emerging field that generalizes multi-objective optimization to any partial ordering induced by a polyhedral cone. We introduce VectOptAL, a treatment within Bayesian optimization frameworks for applying vector Bayesian optimization.

VectOptAL offers a modular structure to work with any probabilistic model. It accommodates active learning in both discrete and continuous domains and can utilize correlated objective formulations. Furthermore, with VectOptAL, we include different acquisition functions tailored for vector Bayesian optimization under either fully or partially observable problems settings.

Bio: Cahit received his BS in Computer Engineering from METU and is an MS student at the Department of EEE at Bilkent University. His current research is aimed at stochastic optimization of complex, unknown systems.

10:30-10:50

Title: Taming the Wild West of AI: Game Theory for Predictable AI Interactions

Presenter: Asst. Prof. Muhammed Ömer Sayın, Bilkent University

Abstract: The rise of AI is transforming social systems, integrating human decision-makers with AI-powered agents in areas like finance and traffic management. This progress is moving our society to the uncharted territory of AI-AI and AI-human (in short, AI-X) interactions, raising concerns about whether self-interested AI with advanced computational capabilities can disrupt these systems. In this talk, I will present the recent steps we have taken toward the foundation of predicting and controlling AI selfishness in complex interactions to address this challenge. I will introduce new learning dynamics based on simple behavioral rules that can converge equilibrium (stable outcomes) in various complex and dynamic AI-X interactions. Our approach applies to scenarios with unknown (stochastic) models, varying observation capabilities, and diverse learning rates. The overarching theme is to use the power of mathematically tractable continuous-time approximation of discrete-time dynamics thanks to the robustness of learning algorithms to vanishing changes. This research paves the way for developing reliable multi-agent AI systems for complex and dynamic social interactions.

Bio: Muhammed Omer Sayin is an Assistant Professor at Bilkent University, with prior research experience at Massachusetts Institute of Technology (MIT) and Toyota InfoTech Labs, Mountain View, CA. He got his Ph.D. from the University of Illinois at Urbana-Champaign (UIUC) in 2019 and his M.S. and B.S. from Bilkent University in 2015 and 2013, respectively. His research primarily focuses on developing the theoretical foundations for intelligent systems that learn and adapt in complex, interconnected environments.

10:50-11:10

Title: Inverse Decision Modeling: Learning Interpretable Representations of Behavior

Presenter: Alihan Hüyük, University of Cambridge

Abstract: Modeling and enhancing decision-making processes is a fundamental concern in many domains, including healthcare, education, and economics. In improving behavior, the crucial first step is to obtain a transparent description of current practices and the imperfections that might necessitate correcting. Most existing work on imitation learning (i.e. to replicate expert actions) and apprenticeship learning (i.e. to match expert returns) offers limited help when the objective is instead in understanding (i.e. to interpret imperfect behavior). Inverse decision modeling goes beyond the utility-driven rational and stationary agents common in the literature: It seeks to (i) explain behavior through decision boundaries, (ii) quantify intuitive notions of bounded rationality such as the apparent flexibility of decisions, tolerance for surprise, or optimism in beliefs, and (iii) give interpretable accounts of how behavior has evolved as decision-makers fine-tune their knowledge over time.

Bio: Alihan is a final-year PhD student at the University of Cambridge supervised by Prof Mihaela van der Schaar. His research mainly focuses on sequential decision-making problems. He is particularly interested in building interpretable models of how humans make decisions in healthcare scenarios, and designing new policies for running adaptive clinical trials. Prior to Cambridge, he completed a BSc in electrical and electronics engineering at Bilkent University. There, he had the opportunity to work on multi-armed bandit problems in combinatorial and multi-objective settings under the supervision of Prof Cem Tekin.

11:10-11:30

Title: Convergence Analysis of a Norm Minimization-Based Convex Vector Optimization Algorithm

Presenter: Muhammad Umer, National University of Science and Technology, Pakistan

Abstract: In this work, we propose an outer approximation algorithm for solving bounded convex vector optimization problems (CVOPs). The algorithm is similar to the Benson-type outer approximation algorithms and is based on solving norm-minimizing scalarizations. For a predetermined tolerance $\epsilon > 0$, we prove that the algorithm terminates after finitely many iterations, and it returns a polyhedral outer approximation to the upper image of the CVOP such that the Hausdorff distance between the two is less than ϵ. We show that for an arbitrary norm used in the scalarization models, the approximation error after k iterations decreases by the order of $O(k^{1/(1-q)})$, where q is the dimension of the objective space. To the best of our knowledge, this algorithm is the first CVOP algorithm with a known convergence rate. We also show an improved convergence rate of $O(k^{2/(1-q)})$ for the special case of using the Euclidean norm.

Bio: Muhammad Umer is currently an assistant professor in the Department of Industrial Engineering at National University of Sciences and Technology (NUST), Pakistan. He received his B.S. and M.S. degrees in Aeronautical and Aerospace Engineering at NUST and Air University in 2007 and 2013, respectively. He received his Ph.D. degree in Industrial Engineering at Bilkent University in 2022. His research interests include vector optimization, set optimization and convex analysis.

11:30-11:50

Title: Robust Bayesian Satisficing

Presenter: Artun Saday, Bilkent University

Abstract: Distributional shifts pose a significant challenge to achieving robustness in contemporary machine learning. To overcome this challenge, robust satisficing (RS) seeks a robust solution to an unspecified distributional shift while achieving a utility above a desired threshold. This paper focuses on the problem of RS in contextual Bayesian optimization when there is a discrepancy between the true and reference distributions of the context. We propose a novel robust Bayesian satisficing algorithm called RoBOS for noisy black-box optimization. Our algorithm guarantees sublinear lenient regret under certain assumptions on the amount of distribution shift. In addition, we define a weaker notion of regret called robust satisficing regret, in which our algorithm achieves a sublinear upper bound independent of the amount of distribution shift. To demonstrate the effectiveness of our method, we apply it to various learning problems and compare it to other approaches, such as distributionally robust optimization.

Bio: Artun Saday completed his Bachelor's degree in Electrical and Electronics Engineering at Bilkent University and is currently pursuing an MSc degree in the same field. His research is centered on Bayesian optimization, Gaussian processes, and robust decision-making under uncertainty.