Machine Learning Needs Optimization: Recent Optimization Models in Kernel Learning and Deep Learning and Applications in Multidisciplinary Projects

Assoc. Prof. Dr. Süreyya Akyüz

Faculty of Engineering and Natural Sciences, Bahçeşehir University Istanbul, Turkey

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Abstract

Optimization plays a crucial role in machine learning methods. The very early and simple methods in statistical learning minimize the error (loss function) in model prediction such as in regression problems. Since machine learning algorithms make predictions from an observed data, most of the machine learning methods minimize loss function with some additional side constraints depending on the algorithm itself.

In this lecture series, I will first introduce basic concepts of machine learning algorithms and the basics of optimization theory. The second lecture will continue with the interplay of optimization and machine learning at a more advanced level where recent optimization models arise in deep learning and kernel learning will be introduced. The third lecture will dive into the applications of methods given in the second lecture by real-world problems such as in healthcare, neuroscience, marketing, and finance. Furthermore, I will point out some applied projects where I completed already and some ongoing studies too.

Süreyya Akyüz received her BSc. (2002) from Middle East Technical University, Department of Mathematics. She got her Msc (2005) and Ph.D. degree from the Scientific Computing program of the Institute of Applied Mathematics at Middle East Technical University. She studied mathematical modeling of biological systems by Differential Algebraic Equations (DAE) in her Msc where she developed a DAE model and hyperparameter optimization with bioinspired algorithms such as Genetic Algorithm for modeling enzymatic reactions. Her doctoral thesis mainly continued with the modeling of biological problems via data mining and machine learning methods. She developed a model which predicts fungal pro-peptide cleavage sites using machine learning techniques, specifically Support Vector Machines (SVM). She investigated SVM and kernel learning in her Ph.D. and build up a novel model called Infinite Kernel Learning via Semi-infinite Optimization. During her Ph.D., she contributed as a research fellow at Vision and Pattern Analysis (VPA) Lab. at Sabancı University. After her Ph.D., she continued her career as Assistant Prof at Bahcesehir University at the Department of Mathematics and Computer Science in 2009. She was awarded by Marie Curie Intra European Fellowship Programme in 2011 and she spent her research at the University of Surrey, UK (2011-2013) at Centre for Vision, Speech and Signal Processing (CVSSP) where she investigated pruning Error-Correcting Output Codes (ECOC) for multi-class classification problems. During the same period, she involved in the EU 7th Framework project (2011-2013) run by Heidelberg University, Germany which was on mathematical modeling of signal transduction pathways of Hepatit C virus. Her role in this project was being a partner participating from Turkey and she contributed to the project with a graph-based algorithm to find an optimal pathway. After her return to Bahcesehir University, she continued her studies on Machine Learning (ML) and Optimization and she has been awarded three national funded TUBITAK R&D projects as principal investigator on both theoretical ML and Optimization and applied areas such as developing an ensemble of deep learning architectures, pruning via second-order conic programming and machine learning applications in neuroscience. She has been awarded Associate Professor in 2016 at Bahcesehir University and since 2018 she has been running head of the Department of Mathematics. She has recently completed a TUBITAK project on applications of biomedical problems such as the relation of obesity with neuroscience via deep learning. She has been supervising undergraduate, MSc and Ph.D. students in different disciplines of multidisciplinary projects. She has been awarded a full Professorship since 2021 at Bahcesehir University. Her publications vary from computer science and optimization to different application areas such as bioinformatics, neuroscience and business applications in ML and OR. Since 2007 she has organized streams and sessions on ML and Its Applications at EURO and IFORS conferences. Her research interests mainly include machine learning, optimization for machine learning algorithms, computational biology and data mining and its applications to engineering problems.