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Braverman Readings
in Machine Learning

Key Ideas from Inception to Current State

International Conference Commemorating
the 40th Anniversary of Emmanuil Braverman's Decease
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Invited Talks

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Cover illustration: Example detector data from the Daya Bay Reactor Neutrino experiment (p. 287, Fig. 14)

Preface

The monograph is dedicated to the memory of Emmanuil Markovich Braverman (1931–1977), a pioneer in developing the machine learning theory. The very term "machine learning" was introduced by him (see, for example, Braverman and Arkadiev, Machine Learning for Classification of Objects, Moscow, published in 1971 by Nauka Publishers, (1st Edition 1964, in Russian). E. M. Braverman was the first to propose a geometrical interpretation of the problem of pattern recognition as a problem of finding compact classes of points in the feature space. He, with co-authors, proposed the method of potential functions, later dubbed "kernels," to perform what is called "the kernel trick," so that the complex problem of separation of patterns is converted into a linear hyperplane separation problem. Main theorems stating convergence of the method of potential functions for pattern recognition, both supervised and unsupervised, have been proved by Braverman and co-authors. Overall, Braverman's work featured an emphasis on the geometric nature, as well as interpretational aspects, of the proposed approaches and methods. E. M. Braverman's work was halted by his untimely death at the age of 46, at the very dawn of data science.

This volume is a tribute to Braverman's memory and an overview of some of his ideas and approaches today. These papers were presented at the conference "Braverman Readings in Machine Learning: Key Ideas from Inception to Current State" held during April 28–30, 2017, at the Northeastern University in Boston. This conference marked the 40th anniversary of the death of E. M. Braverman. The conference program and related materials can be found on the conference website at https://yandexdataschool. com/conference/2017/about. Both the conference and this publication were supported by Yandex, a pioneering search technology company and provider of intelligent products and services powered by machine learning. From its very inception more than 20 years ago, Yandex has been honoring the legacy of E. M. Braverman.

The collection is divided in three parts.

The first part bridges the past and present. Its main content relates to the concept of kernel function and its application to signal and image analysis (Sulimova and Mottl; Mottl, Seredin and Krasotkina; Vovk, Nouretdinov, Manokhin and Gammerman; and Aizerman, Braverman and Rozonoer), as well as clustering (Mirkin), bringing together the first, naive, attempts with matured mathematics-loaded approaches. Rozonoer describes an approach to the issue of data complexity. Mandel develops an interesting computational approach to causality modeling by using "immediate" causes as regressors.

The second part presents a set of extensions of Braverman's work to issues of current interest both in theory and applications of machine learning. Applications range from natural sciences (Bottou, Arjovsky, Lopez-Paz, and Oquab) to drug design (Borisov, Tkachev, Buzdin, and Muchnik) to robot motion planning (Lumelsky). Among machine learning theory issues are one-class learning (see E. Bauman and K. Bauman), various distances between distributions (Bottou, Arjovsky, Lopez-Paz,

Oquab), and deep learning mechanisms (Sadowski and Baldi, as well as Agostinelli, Hocquet, Singh and Baldi).

The third part, on E. M. Braverman's personality and his circle, is intentionally made brief. It includes short essays by a friend, L. Rozonoer, a student, M. Levin, and a colleague, B. Mirkin. These also shed light on another aspect of E. M. Braverman's research — his deep insights into modeling of an unbalanced economy, like that of the Soviet Union back in the 1950s to 1970s, in which no free price adjustment was permitted, and the only method of balancing was by using production and consumption quotas (see Levin). The final material is a list of refereed papers published by E. M. Braverman in the *Automation and Remote Control* journal and available in English.

The material in this volume is instructive for several segments of the audience. Most of all, it is oriented at students, developers, and practitioners in machine learning and data analysis. They will find in the volume a number of constructive ideas regarding issues of current interest for the analysis of data of complex structure. The presented material provides useful insights into the role of parameters, such as the number of clusters or a threshold, which are usually considered sealed in the algorithms, but in fact should be open to user–machine interaction. The book will be interesting to historians too.

Reference

A.G. Arkadiev, E.M. Braverman (1971) *Machine Learning for Classification of Objects*, Moscow, The Main Editorial of Physics and Mathematics Literature, Nauka Publishers, 192 p. (In Russian, 1st Edition 1964).

May 2018   Lev Rozonoer
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