

Lecture Notes in Artificial Intelligence

11100

Subseries of Lecture Notes in Computer Science

LNAI Series Editors

Randy Goebel

University of Alberta, Edmonton, Canada

Yuzuru Tanaka

Hokkaido University, Sapporo, Japan

Wolfgang Wahlster

DFKI and Saarland University, Saarbrücken, Germany

LNAI Founding Series Editor

Joerg Siekmann

DFKI and Saarland University, Saarbrücken, Germany

More information about this series at <http://www.springer.com/series/1244>

Lev Rozonoer · Boris Mirkin
Ilya Muchnik (Eds.)

Braverman Readings in Machine Learning

Key Ideas from Inception to Current State

International Conference Commemorating
the 40th Anniversary of Emmanuil Braverman's Decease
Boston, MA, USA, April 28–30, 2017
Invited Talks

Editors

Lev Rozonoer
West Newton, MA
USA

Ilya Muchnik
Rutgers University
Piscataway, NJ
USA

Boris Mirkin 
National Research University Higher School
of Economics
Moscow
Russia

ISSN 0302-9743 ISSN 1611-3349 (electronic)
Lecture Notes in Artificial Intelligence
ISBN 978-3-319-99491-8 ISBN 978-3-319-99492-5 (eBook)
<https://doi.org/10.1007/978-3-319-99492-5>

Library of Congress Control Number: 2018952242

LNCS Sublibrary: SL7 – Artificial Intelligence

© Springer Nature Switzerland AG 2018, corrected publication 2018

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

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

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

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
Boris Mirkin
Ilya Muchnik

Organization

Program Committee

Boris Mirkin (Chair)	National Research University Higher School of Economics in Moscow, Russia, and Birkbeck, University of London, UK
Pierre Baldi	University of California, Irvine, USA
Leon Bottou	Facebook, USA
Alexander Gammerman	Royal Holloway, University of London, USA
Ilya Muchnik	Rutgers University, NJ, USA and Yandex School of Data Analysis, Moscow, Russia
Vladimir Vapnik	Facebook, USA
Vladimir Vovk	Royal Holloway, University of London, UK

Organizing Committee

Elena Bunina	Yandex School of Data Analysis, Moscow, Russia
Ilya Muchnik	Yandex School of Data Analysis, Moscow, Russia
Evgenia Kulikova	Yandex School of Data Analysis, Moscow, Russia
Elena Schiryayeva	Yandex School of Data Analysis, Moscow, Russia

Acknowledgments

The Editors express their sincere gratitude to the organizations and individuals whose help was crucial in bringing the Conference and the volume into reality.

Our biggest thanks go to

The logo for Yandex, featuring a large red 'Y' followed by the word 'andex' in black lowercase letters.

a pioneering search technology company and provider of intelligent products and services, and Yandex' representative, Evgenia Kulikova, Head of Academic Programs Services, Yandex, Russia.

We are also grateful to: Prof. Maxim Braverman, Northeastern University, USA, Prof. Alexander Gammerman, Royal Holloway, University of London, UK, and Benjamin Rozonoyer, Brandeis University, USA.

Contents

Bridging Past and Future

Potential Functions for Signals and Symbolic Sequences	3
<i>Valentina Sulimova and Vadim Mottl</i>	
Braverman’s Spectrum and Matrix Diagonalization Versus iK-Means: A Unified Framework for Clustering	32
<i>Boris Mirkin</i>	
Compactness Hypothesis, Potential Functions, and Rectifying Linear Space in Machine Learning	52
<i>Vadim Mottl, Oleg Seredin, and Olga Krasotkina</i>	
Conformal Predictive Distributions with Kernels	103
<i>Vladimir Vovk, Ilia Nouretdinov, Valery Manokhin, and Alex Gammerman</i>	
On the Concept of Compositional Complexity	122
<i>Lev I. Rozonoer</i>	
On the Choice of a Kernel Function in Symmetric Spaces	128
<i>M. A. Aizerman, E. M. Braverman, and Lev I. Rozonoer</i>	
Causality Modeling and Statistical Generative Mechanisms	148
<i>Igor Mandel</i>	

Novel Developments

One-Class Semi-supervised Learning	189
<i>Evgeny Bauman and Konstantin Bauman</i>	
Prediction of Drug Efficiency by Transferring Gene Expression Data from Cell Lines to Cancer Patients	201
<i>Nicolas Borisov, Victor Tkachev, Anton Buzdin, and Ilya Muchnik</i>	
On One Approach to Robot Motion Planning	213
<i>Vladimir Lumelsky</i>	
Geometrical Insights for Implicit Generative Modeling	229
<i>Leon Bottou, Martin Arjovsky, David Lopez-Paz, and Maxime Oquab</i>	
Deep Learning in the Natural Sciences: Applications to Physics	269
<i>Peter Sadowski and Pierre Baldi</i>	

From Reinforcement Learning to Deep Reinforcement Learning:
An Overview 298
Forest Agostinelli, Guillaume Hocquet, Sameer Singh, and Pierre Baldi

Personal and Beyond

A Man of Unlimited Capabilities (in Memory of E. M. Braverman) 331
Lev I. Rozonoer

Braverman and His Theory of Disequilibrium Economics. 333
Mark Levin

Misha Braverman: My Mentor and My Model 341
Boris Mirkin

List of Braverman’s Papers Published in the “Avtomatika i telemekhanika”
Journal, Moscow, Russia, and Translated to English as “Automation
and Remote Control” Journal 349
Ilya Muchnik

Correction to: Braverman and His Theory of Disequilibrium Economics E1
Mark Levin

Author Index 353