

## Machine Learning and Wireless Communications

How can machine learning help the design of future communication networks, and how can future networks meet the demands of emerging machine learning applications? Discover the interactions between two of the most transformative and impactful technologies of our age in this comprehensive book.

First, learn how modern machine learning techniques, such as deep neural networks, can transform how we design and optimize future communication networks. Accessible introductions to concepts and tools are accompanied by numerous real-world examples, showing you how these techniques can be used to tackle longstanding problems. Next, explore the design of wireless networks as platforms for machine learning applications. An overview of modern machine learning techniques and communication protocols will help you to understand the challenges, while new methods and design approaches will be presented to handle wireless channel impairments such as noise and interference, to meet the demands of emerging machine learning applications at the wireless edge.

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Cambridge University Press & Assessment

978-1-108-83298-4 — Machine Learning and Wireless Communications

Edited by Yonina C. Eldar , Andrea Goldsmith , Deniz Gündüz , H. Vincent Poor

Frontmatter

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# Machine Learning and Wireless Communications

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CAMBRIDGE  
UNIVERSITY PRESS

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## CAMBRIDGE UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom  
One Liberty Plaza, 20th Floor, New York, NY 10006, USA  
477 Williamstown Road, Port Melbourne, VIC 3207, Australia  
314–321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre, New Delhi – 110025, India  
103 Penang Road, #05–06/07, Visioncrest Commercial, Singapore 238467

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning, and research at the highest international levels of excellence.

[www.cambridge.org](http://www.cambridge.org)

Information on this title: [www.cambridge.org/9781108832984](http://www.cambridge.org/9781108832984)

DOI: 10.1017/9781108966559

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First published 2022

Printed in the United Kingdom by TJ Books Limited, Padstow Cornwall

*A catalogue record for this publication is available from the British Library.*

*Library of Congress Cataloging-in-Publication Data*

Names: Eldar, Yonina C., editor.

Title: Machine learning and wireless communications / edited by Yonina C. Eldar, Weizmann Institute of Science, Andrea Goldsmith, Princeton University, Deniz Gündüz, Imperial College, H. Vincent Poor, Princeton University.

Description: First edition. | Cambridge, United Kingdom ; New York, NY :

Cambridge University Press, 2022. | Includes bibliographical references and index.

Identifiers: LCCN 2021063108 (print) | LCCN 2021063109 (ebook) |

ISBN 9781108832984 (hardback) | ISBN 9781108966559 (epub)

Subjects: LCSH: Wireless communication systems. | Machine learning. |

BISAC: TECHNOLOGY & ENGINEERING / Signals & Signal Processing

Classification: LCC TK5103.2 .M3156 2022 (print) | LCC TK5103.2 (ebook) |

DDC 621.382–dc23/eng/20220318

LC record available at <https://lcn.loc.gov/2021063108>

LC ebook record available at <https://lcn.loc.gov/2021063109>

ISBN 978-1-108-83298-4 Hardback

Cambridge University Press has no responsibility for the persistence or accuracy of URLs for external or third-party internet websites referred to in this publication and does not guarantee that any content on such websites is, or will remain, accurate or appropriate.

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**To our families.**

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## Preface

Machine learning (ML) and wireless communications are two of the most rapidly advancing technologies of our time. The main premise of ML is to enable computers to learn and perform certain tasks without being explicitly programmed to do so. This is achieved by training algorithms on data available for the task to be accomplished. Although the basic ideas and ambitions of ML go back to the 1950s, there has been a recent surge in interest and applications in this area, fueled by the availability of increasingly powerful computers, large amounts of data, and developments in new learning algorithms as well as their theoretical underpinnings. At the same time, wireless communication has evolved, through advances in both theory and supporting technologies, to encompass a variety of application areas, from high-performance data transmission tasks such as media distribution to the massive deployment of end-devices to enable Internet of Things (IoT) tasks such as sensing, inference, and control.

We are now witnessing the confluence of these two fields, with two primary aspects to this connection. One is the application of ML techniques to the optimization of wireless networks. This is a natural use of ML, as wireless networks involve many inferential and control tasks, which often must operate under dynamic or uncertain conditions, and create many exemplars for learning because data transmissions take place at very high rates. The other aspect of this connection is the use of wireless networks as ML platforms. This again is a natural application of emerging wireless networks, such as those supporting IoT applications, because they involve sensing, inference, and control and provide edge devices with considerable processing power. Learning at the network edge has advantages in terms of latency and privacy, and it capitalizes on the fact that many learning tasks, such as those supporting automated driving, are locality specific.

To realize the promise of these opportunities, significant research in many dimensions is needed. Important issues include the adaptation of existing ML techniques to wireless system design and the design and development of new techniques that can meet the constraints and requirements of communication networks, including the capability to implement at least some of these techniques in low-power chips that can be used in mobile devices, as well as developing fundamental analytical techniques and bounds on the performance of distributed ML algorithms operating within the constraints of wireless connectivity. This book focuses on these research issues through a series of 18 chapters written by experts in the field, beginning with an introductory chapter providing a brief general overview of ML methodology. By presenting a

systematic overview of the most promising aspects of the connection between ML in wireless networks, this book provides an entry point and a comprehensive overview of the state of the art for researchers in academia and industry who are interested in learning and contributing to this growing field.

This book is the culmination of the efforts of many people, including the chapter authors and the editorial and production staff at Cambridge University Press. We wish to express our deep gratitude for their contributions.