

# Lecture Notes in Artificial Intelligence

9605

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Andreas Holzinger (Ed.)

# Machine Learning for Health Informatics

State-of-the-Art and Future Challenges

 Springer

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## About the Editor

Andreas Holzinger is lead of the Holzinger Group, HCI–KDD, Institute for Medical Informatics, Statistics and Documentation at the Medical University Graz, and Associate Professor of Applied Computer Science at the Faculty of Computer Science and Biomedical Engineering at Graz University of Technology. Currently, Andreas is Visiting Professor for Machine Learning in Health Informatics at the Faculty of Informatics at Vienna University of Technology. He serves as consultant for the Canadian, US, UK, Swiss, French, Italian and Dutch governments, for the German Excellence Initiative, and as national expert in the European Commission. His research interests are in supporting human intelligence with machine intelligence to help solve problems in health informatics. Andreas obtained a PhD in Cognitive Science from Graz University in 1998 and his Habilitation (second PhD) in Computer Science from Graz University of Technology in 2003. Andreas was Visiting Professor in Berlin, Innsbruck, London (twice), and Aachen. He founded the Expert Network HCI–KDD to foster a synergistic combination of methodologies of two areas that offer ideal conditions toward unraveling problems in understanding intelligence: Human–Computer Interaction (HCI) and Knowledge Discovery/Data Mining (KDD), with the goal of supporting human intelligence with machine learning. Andreas is Associate Editor of *Knowledge and Information Systems* (KAIS), Section Editor of *BMC Medical Informatics and Decision Making* (MIDM), and member of IFIP WG 12.9 Computational Intelligence: <http://hci-kdd.org>.

# Preface

Machine learning (ML) studies algorithms that can learn from data to gain knowledge from experience and to make decisions and predictions. Health Informatics (HI) studies the effective use of probabilistic information for decision making. Consequently, to bridge these two fields is of eminent importance for improving human health and well-being.

As a matter of fact, the discipline of health is increasingly turning into a data science and health systems worldwide are confronted with big data. This may be beneficial, as algorithms that improve through experience from large data sets can be of great help here, and automatic ML (aML) approaches show impressive results. Moreover, much health data are in arbitrarily high dimensions, where manual analysis is simply impossible, hence fully automatic approaches by taking the human-out-of-the-loop make great sense.

However, sometimes we are confronted with small data sets, or rare events, where aML approaches suffer from insufficient training samples. Here interactive ML (iML) may be of help, which can be defined as algorithms that can interact with agents and can optimize their learning behavior through these interactions, where the agents can also be human. Furthermore, such a human in the loop can be beneficial in solving computationally hard problems. Particularly a doctor-in-the-loop can be helpful, e.g., in subspace clustering, protein folding, or k-anonymization, where human expertise can help reduce an exponential search space through heuristic selection of samples. Therefore, what would otherwise remain an NP-hard problem, may decrease greatly in complexity by making use of human intelligence and human intuition involved in the ML pipeline.

Intelligence is the core topic of research and Demis Hassabis from Google DeepMind summarizes it precisely within his mission statement: “Solve intelligence. Then solve everything else.” A synergistic combination of methodologies and approaches from two areas attack the challenge of “solving intelligence” from two perspectives: Human Computer Interaction (HCI) and Knowledge Discovery and Data Mining (KDD).

Consequently, this HCI–KDD approach fosters the successful application of machine learning for health informatics, by encouraging an integrated approach, promoting a concerted cross-disciplinary effort of experts from various disciplines, including (1) data science, (2) algorithms, (3) network science, (4) topology, (5) time/entropy, (6) data visualization, and last but not least (7) privacy, data protection, safety and security.

Hence, the mission of the HCI–KDD expert network is to bring together professionals from diverse areas with various backgrounds and different views, but who share a common vision: “solving intelligence,” following the HCI–KDD motto “Science is to test crazy ideas – engineering is to bring those ideas into business.”

The HCI–KDD expert network organizes special sessions, the first took place in Graz (Austria), the second in Macau (China), the third in Maribor (Slovenia), the fourth in Regensburg (Germany), the fifth in Lisbon (Portugal), the sixth in Warsaw (Poland), the seventh in Banff (Canada), the eighth in London (UK), the ninth in Salzburg (Austria), and the tenth is planned to take place in Reggio di Calabria (Italy) in summer 2017.

Volume 9605 of the *Lecture Notes in Computer Science* series is a state-of-the-art survey (SOTA) and an output of the international HCI–KDD expert network. The volume features 22 carefully selected and peer-reviewed chapters on hot topics in ML for HI. Each chapter discuss open problems and future challenges in order to stimulate further research and international progress in this field.

To acknowledge here all those who contributed to the efforts and stimulating discussions would be impossible. Many people contributed to the development of this volume, either directly or indirectly, and it would be simply impossible to list all of them, so let me thank my international, national, and local colleagues, my family and friends for all their nurturing and positive encouragement. Last but not least I thank the Springer management team and the Springer production team for their smooth support; a cordial thank you to all!

October 2016

Andreas Holzinger

# Organization

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I am grateful for the support of all members of the expert network HCI-KDD, <http://hci-kdd.org/international-expert-network>

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