# Preface

Vladimir Vapnik is a rare example of a scientist for whom the following three statements hold true simultaneously: his work has led to the inception of a whole new field of research, he has lived to see the field blossom and gain in popularity, and he is still as active as ever in his field.

His field, the theory of statistical learning and empirical inference, did not exist when he started his PhD in Moscow in the early 1960s. He was working at the Institute of Control Sciences of the Russian Academy of Sciences under the supervision of Professor Aleksandr Lerner, a cyberneticist and expert in control theory who was later to become a prominent “Refusenik” (a Soviet Jew who was denied permission to emigrate by the Soviet government). Vladimir Vapnik started analyzing learning algorithms and invented the first version of a pattern recognition algorithm termed the “Generalized Portrait”, whose successor (the “Support Vector Machine”, co-invented by him 30 years later) would become the method of choice in many pattern recognition problems ranging from computer vision to bioinformatics. Following this, he started to collaborate with Aleksey Chervonenkis, also a PhD student in Lerner’s laboratory at the time, on the Generalized Portrait and the theory of the empirical risk minimization inductive principle.

Vapnik and Chervonenkis found a stimulating intellectual environment at the Institute of Control Sciences. In 1951 Vadim Trapeznikov was appointed as the institute’s director, and it is largely due to his efforts that in the early 1960s it became a hub of new ideas and creativity. It included Mark Aizerman’s laboratory, working on the theory of learning systems and having Emmanuel Braverman and Lev Rozonoer among its members, as well as Lerner’s laboratory, where Vapnik and Chervonenkis carried out their work that would lead to profound changes in our understanding of machine learning.

The impact of Vapnik and Chervonenkis’s work has been considerable in many areas of mathematics and computer science. In theoretical statistics and probability theory, their work is known for extensions of the Glivenko–Cantelli theorem and for uniform laws of large numbers. The latter can be considered as the starting point of an important branch of probability theory, the theory of empirical processes.

The introduction of certain classes of functions (now called Vapnik–Chervonenkis classes) and of the notion now referred to as Vapnik–Chervonenkis, or VC, dimension was a key contribution to this area, relating concepts from analysis (approximation properties of classes of functions) to combinatorial parameters. Also, it was the starting point of what Vapnik called "statistical learning theory", an interdisciplinary field combining mathematical statistics and machine learning. The revolutionary aspect of this theory, when introduced, was that it focused on non-asymptotic estimation properties of non-parametric classes.

The main achievement of Vapnik and Chervonenkis's development of this theory was the introduction and analysis of the inductive principle called "empirical risk minimization." This principle suggests that, given data and a class of functions, we should choose the function that minimizes the error on the data (in other words, the minimizer of the "training error"). Their work on this inductive principle culminated in obtaining necessary and sufficient conditions for its consistency (i.e., the principle asymptotically leading to optimal estimation), related to the validity of a uniform law of large numbers. They also showed how to relate the uniform law to notions of the "capacity" of the function classes used, such as the VC dimension. In machine learning theory, this gave rise to a sizeable community of researchers computing bounds on or estimates of the VC dimension for most popular function classes, such as neural networks or decision trees.

Following the analysis of empirical risk minimization, Vladimir Vapnik developed an improved inductive principle called "structural risk minimization," which underlies a large number of today's learning algorithms, and significantly contributed to the birth of the research area of model selection in statistics.

As recognition of his groundbreaking work in the theory and applications of pattern recognition, Vladimir Vapnik was awarded the Prize of the USSR Council of Ministers, an achievement which is particularly outstanding considering that Vladimir's career in the USSR was hampered significantly due to his being Jewish.

In 1991, after the coup to overthrow Gorbachev had just taken place, Vladimir decided to emigrate to the USA, where he joined the Adaptive Systems Research Department at AT&T Bell Laboratories. There, he and his co-workers developed one of the most successful methods in machine learning, the Support Vector Machine. Based on an ingenious combination of methods from statistical learning (the Generalized Portrait algorithm) and functional analysis (the theory of positive definite kernels), it transformed the field of machine learning. More than just an algorithm, it is a whole approach to learning problems, pioneering the use of functional analysis and convex optimization in machine learning. It has meanwhile set world records on a variety of real-world pattern-recognition benchmark problems. This success has attracted a large number of researchers as well as engineers from various disciplines to the field of statistical learning theory.

Vladimir has continued to develop the theory of support vector machines in unexpected directions. For example, in 2006 he came up with the idea of using "privileged information" in machine learning: information that is available only at the training stage. In a surprisingly wide range of applications such information improves the performance of learning algorithms.

Vladimir's work has found wide recognition throughout the world. In 2003 his groundbreaking work in theoretical and applied statistics and machine learning was recognized with the Alexander Humboldt Research Award. He received the 2005 Gabor Award of the International Neural Network Society. In 2006 he was elected a member of the United States National Academy of Engineering "for insights into the fundamental complexities of learning and for inventing practical and widely applied machine-learning algorithms". In 2008 he received, together with Corinna Cortes, the Paris Kanellakis Award from the Association for Computing Machinery "for the development of Support Vector Machines, a highly effective algorithm for classification and related machine learning problems". In 2010 came the Neural Networks Pioneer Award from the IEEE Computational Intelligence Society. In 2012 Vladimir was honoured with the IEEE Frank Rosenblatt Award "for development of support vector machines and statistical learning theory as a foundation of biologically inspired learning". In the same year he was awarded the Benjamin Franklin Medal in Computer and Cognitive Science by the Franklin Institute "for his fundamental contributions to our understanding of machine learning, which allows computers to classify new data based on statistical models derived from earlier examples, and for his invention of widely used machine learning techniques".

Vladimir has published a number of papers and books that are considered classics. His monographs contain not only a comprehensive account of statistical learning theory and its applications, but they also host a wealth of original and unexplored directions for future research and improvements.

It is remarkable for the development of humankind that we have now arrived at a point where there exist regularities (non-random structures) in the world that are so complex that they cannot be detected by humans, yet they can reliably be learnt by machine learning methods. We believe this will have a transformative effect on our interaction with the world, and we cannot think of an individual whose impact on this transformation has been larger than that of Vladimir Vapnik.

Vladimir's impact on the machine learning community, both through his technical contributions and his philosophy of research as conveyed by numerous keynote talks, has been so large that his standing in the field is that of a living legend. There is no doubt that he will continue to have a profound influence on the field of machine learning, as more and more of his ideas are being put into practice.

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