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IFIP – The International Federation for Information Processing

IFIP was founded in 1960 under the auspices of UNESCO, following the First World Computer Congress held in Paris the previous year. An umbrella organization for societies working in information processing, IFIP's aim is two-fold: to support information processing within its member countries and to encourage technology transfer to developing nations. As its mission statement clearly states,

> IFIP's mission is to be the leading, truly international, apolitical organization which encourages and assists in the development, exploitation and application of information technology for the benefit of all people.

IFIP is a non-profitmaking organization, run almost solely by 2500 volunteers. It operates through a number of technical committees, which organize events and publications. IFIP's events range from an international congress to local seminars, but the most important are:

- The IFIP World Computer Congress, held every second year;
- Open conferences;
- Working conferences.

The flagship event is the IFIP World Computer Congress, at which both invited and contributed papers are presented. Contributed papers are rigorously refereed and the rejection rate is high.

As with the Congress, participation in the open conferences is open to all and papers may be invited or submitted. Again, submitted papers are stringently refereed.

The working conferences are structured differently. They are usually run by a working group and attendance is small and by invitation only. Their purpose is to create an atmosphere conducive to innovation and development. Refereeing is also rigorous and papers are subjected to extensive group discussion.

Publications arising from IFIP events vary. The papers presented at the IFIP World Computer Congress and at open conferences are published as conference proceedings, while the results of the working conferences are often published as collections of selected and edited papers.

Any national society whose primary activity is about information processing may apply to become a full member of IFIP, although full membership is restricted to one society per country. Full members are entitled to vote at the annual General Assembly, National societies preferring a less committed involvement may apply for associate or corresponding membership. Associate members enjoy the same benefits as full members, but without voting rights. Corresponding members are not represented in IFIP bodies. Affiliated membership is open to non-national societies, and individual and honorary membership schemes are also offered.

Harris Papadopoulos Andreas S. Andreou
Lazaros Iliadis Ilias Maglogiannis (Eds.)

Artificial Intelligence Applications and Innovations

9th IFIP WG 12.5 International Conference, AIAI 2013
Paphos, Cyprus, September 30 – October 2, 2013
Proceedings

Springer

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Preface

This volume contains the papers accepted for presentation at the 9th IFIP International Conference on Artificial Intelligence Applications and Innovations (AIAI 2013), which was held in Paphos, Cyprus, during September 30 to October 2, 2013. AIAI is the official conference of the IFIP Working Group 12.5 "Artificial Intelligence Applications" of the IFIP Technical Committee on Artificial Intelligence (TC12). IFIP was founded in 1960 under the auspices of UNESCO, following the first World Computer Congress, held in Paris the previous year. The first AIAI conference was held in Toulouse, France in 2004 and since then it has been held annually, offering scientists the chance to present different perspectives on how artificial intelligence (AI) may be applied and offer solutions to real-world problems.

The importance of artificial intelligence is underlined by the fact that it is nowadays being embraced by a vast majority of research fields across different disciplines, from engineering sciences to economics and medicine, as a means to tackle highly complicated and challenging computational as well as cognitive problems. Being one of the main streams of information processing, artificial intelligence may now offer solutions to such problems using advances and innovations from a wide range of sub-areas that induce thinking and reasoning in models and systems.

AIAI is a conference that grows in significance every year attracting researchers from different countries around the globe. It maintains high quality standards and welcomes research papers describing technical advances and engineering and industrial applications of artificial intelligence. AIAI is not confined to introducing how AI may be applied in real-world situations, but also includes innovative methods, techniques, tools and ideas of AI expressed at the algorithmic or systemic level.

In 2013 the AIAI conference was organized and sponsored by IFIP, the Cyprus University of Technology and Frederick University, Cyprus. Additional sponsorship was also provided by Royal Holloway, University of London, UK and by the Cyprus Tourism Organization. The conference was held in the seaside city of Paphos, Cyprus, a city rich in history and culture.

This volume contains a total of 70 papers that were accepted for presentation at the main event (26 papers) and the 8 workshops of the conference after being reviewed by at least two independent academic referees. The authors of these papers come from 24 different countries, namely: Belgium, Brazil, Canada, China, Cyprus, Egypt, France, Greece, Italy, Japan, Luxembourg, Morocco, The Netherlands, Nigeria, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland, Turkey, The United Kingdom, and The United States.

In addition to the accepted papers, the technical program of the conference featured a symposium titled "Measures of Complexity", which was organized

to celebrate the 75th birthday of Professor Alexey Chervonenkis, one of the most important scholars in the field of pattern recognition and computational learning. The symposium included talks by

- Alexey Chervonenkis (Russian Academy of Sciences, Yandex, Russia, and Royal Holloway, University of London, UK)
- Vladimir Vapnik (NEC, USA and Royal Holloway, University of London, UK)
- Richard Dudley (MIT, USA)
- Bernhard Schölkopf (Max Planck Institute for Intelligent Systems, Germany)
- Leon Bottou (Microsoft Research, USA)
- Konstantin Vorontsov (Russian Academy of Sciences)
- Alex Gammerman (Royal Holloway, University of London, UK)
- Vladimir Vovk (Royal Holloway, University of London, UK)

Furthermore, a keynote lecture was given by Tharam Dillon (La Trobe University, Australia) and Elizabeth Chang (Curtin University, Australia) on "Trust, Reputation, and Risk in Cyber Physical Systems".

A total of 8 workshops were included in the technical program of the conference, each related to a specific topic of interest within AI. These were:

- The 3rd Workshop on Artificial Intelligence Applications in Biomedicine (AIAB 2013) organized by Harris Papadopoulos (Frederick University, Cyprus), Efthyvoulos Kyriacou (Frederick University, Cyprus), Ilias Maglogiannis (University of Piraeus, Greece) and George Anastassopoulos (Democritus University of Thrace, Greece).
- The 2nd Workshop on Conformal Prediction and its Applications (CoPA 2013) organized by Harris Papadopoulos (Frederick University, Cyprus), Alex Gammerman (Royal Holloway, University of London, UK) and Vladimir Vovk (Royal Holloway, University of London, UK).
- The 2nd Workshop on Intelligent Video-to-video Communications in Modern Smart Cities (IVC 2013) organized by Ioannis P. Chochliouros (Hellenic Telecommunications Organization – OTE, Greece), Latif Ladid (University of Luxemburg, Luxemburg), Vishanth Weerakkody (Brunel University, UK) and Ioannis M. Stephanakis (Hellenic Telecommunications Organization – OTE, Greece).
- The 2nd Workshop on Applying Computational Intelligence Techniques in Financial Time Series Forecasting and Trading (ACIFF 2013) organized by Spiridon D. Likothanassis (University of Patras, Greece), Efstratios F. Georgopoulos (Technological Educational Institute of Kalamata, Greece), Georgios Sermpinis (University of Glasgow, Scotland), Andreas S. Karathanasopoulos (London Metropolitan University, UK) and Konstantinos Theofilatos (University of Patras, Greece).
- The 1st Workshop on Fuzzy Cognitive Maps Theory and Applications (FCMTA 2013) organized by Elpiniki Papageorgiou (Technological Educational Institute of Lamia, Greece), Petros Groumpos (University of Patras, Greece), Nicos Mateou (Ministry of Defense, Cyprus) and Andreas S. Andreou (Cyprus University of Technology, Cyprus)

- The 1st Workshop on Learning Strategies and Data Processing in Non-stationary Environments (LEAPS 2013) organized by Giacomo Boracchi (Politecnico di Milano, Italy) and Manuel Roveri (Politecnico di Milano, Italy).
- The 1st Workshop on Computational Intelligence for Critical Infrastructure Systems (CICIS 2013) organized by Christos Panayiotou (KIOS/University of Cyprus, Cyprus), Antonis Hadjiantonis (KIOS/University of Cyprus, Cyprus), Demetrios Eliades (KIOS/University of Cyprus, Cyprus) and Andreas Constantinides (University of Cyprus and Frederick University, Cyprus).
- The 1st Workshop on Ethics and Philosophy in Artificial Intelligence (EPAI 2013) organized by Panayiotis Vlamos (Ionian University, Greece) and Athanasios Alexiou (Ionian University, Greece).

We would like to express our gratitude to everyone who has contributed to the success of the AIAI 2013 conference. In particular, we are grateful to Professors Alex Gammerman and Vladimir Vovk for the organization of the "Measures of Complexity" symposium. Special thanks to the symposium and keynote speakers for their inspiring talks. We would like to express our sincere gratitude to the organizers of the eight workshops for enriching this event with their interesting topics. We would also like to thank the members of the Organizing Committee for their great effort in the organization of the conference and the members of the Program Committee who did an excellent job in a timely manner during the review process. Special thanks are also due to Pantelis Yiasemis and Antonis Lambrou for helping us with the formatting of the final proceedings. We are grateful to the Cyprus University of Technology, Frederick University, Royal Holloway, University of London (Computer Science Department) and the Cyprus Tourism Organization for their financial support. We also thank the conference secretariat, Tamasos Tours, for its important support in the organization of the conference. Finally, we would like to thank all authors for trusting our conference and contributing their work to this volume.

August 2013

Harris Papadopoulos
Andreas S. Andreou
Lazaros Iliadis
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Measures of Complexity

Symposium in Honor of Professor Alexey Chervonenkis
on the Occasion of His 75th Birthday

(Abstracts of Invited Talks)

Professor Alexey Chervonenkis
A Brief Biography

Professor Alexey Chervonenkis has made a long and outstanding contribution to the area of pattern recognition and computational learning. His first book on Pattern Recognition was published in 1974 with Professor Vladimir Vapnik and he has become an established authority in the field. His most important contributions include: The derivation of the necessary and sufficient conditions for the uniform convergence of the frequency of an event to its probability over a class of events. A result that was later developed to the necessary and sufficient conditions for the uniform convergence of means to expectations. The introduction of a new characteristic of a class of sets, later called the VC-dimension. The development of a pattern recognition algorithm called "generalized portrait", which was later further developed to the well-known Support Vector Machine. The development of principles and algorithms for choosing the optimal parameters depending on the available amount of empirical data and the complexity of the decision rule class for the problems of pattern recognition, ridge regression, kernel ridge regression and kriging. Some of these results served as the foundation for many machine learning algorithms.

Professor Chervonenkis obtained his Masters degree in Physics from the Moscow Physical and Technical Institute, Moscow, USSR in 1961 and his PhD in Physical and Mathematical Science from the Computer Centre of the Academy of Sciences of the USSR, Moscow, USSR in 1971. He is currently Head of the Applied Statistical Research Department at the Institute of Control Science, Russian Academy of Sciences. He is also Emeritus Professor at the Computer Learning Research Centre of Royal Holloway, University of London, UK where he has been working as a part-time professor since 2000. Additionally he is a part time Professor at the School of Data Analysis, Moscow, Russia since 2007 and a Scientific Consultant at Yandex, Russia since 2009. Between 1987 and 2005 he served as a Scientific Consultant at the Information Technologies in Geology and Mining (INTEGRA) company (Moscow, Russia). His research interests include the investigation of the properties of set classes and the application of machine learning algorithms to various problems. He has published three monographs and numerous manuscripts in journals and conferences.

Measures of Complexity

Alexey Chervonenkis

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Abstract. Even long ago it was understood that the more is the complexity of a model, the larger should be the size of the learning set. It refers to the problem of function reconstruction based on empirical data, learning to pattern recognition or, in general, model construction using experimental measurements. Probably the first theoretical result here was Nikewest criterion (in Russia Kotelnikov theorem). It stated that, if one wants to reconstruct a continuous function on the basis of a set of measurements at discrete points, then the number of measurements should be proportional to the width of the function spectrum. It means that the spectrum width can serve as one of possible metrics of complexity.

In general, for the given amount of learning data one has to limit himself on a certain level of the model complexity depending on the data volume. But for practical implementation of this idea it is necessary to define general notion of complexity and the way to measure it numerically.

In my works with V. Vapnik we reduced the problem of a learning system ability to generalize data to the problem of the uniform convergence of frequencies to probabilities over a class of events (or means to expectations over a class of functions). If such convergence holds, then the system is able to be learned. But not on the contrary. It is possible that uniform convergence does not hold, but the system still has ability to learn.

Conditions of the uniform convergence are formulated in terms of index of evens class over a given sample, growth function and the so called VC-dimension or entropy. VC-dimension allows get estimates of uniform closeness of frequencies to probabilities, which does not depend on probability distribution over input space. Asymptotic entropy per symbol gives necessary and sufficient conditions of the uniform convergence, but they do depend on the probability distribution. In most important cases VC-dimension is equal or close to the number of unknown model parameters. Very important results in this field were gained by M. Talagran, Rademacher and others.

And still there are cases when a decision rule with large number of parameters is searched, but only a few number of examples is sufficient to find. Let us consider an example of two classes in n-dimensional Euclidean space. Each of the classes is formed by a ball having diameter D, and the distance between the centers of the balls is equal to R. If the ratio between the distance R and the diameter D is large enough

then it is sufficient to show only two examples to reach 100% of correct answers. And it does not depend on the dimension of the space. A similar situation appears for recognition of two classes under supposition of feature independence (and some other conditions). Boosting algorithms construct very large formulas, and in spite of it they reach good results even for limited amount of learning data. All these facts force us to search new measures of complexity, which are not directly connected to the notion of uniform convergence. It seems that they should depend on the probability distribution. But that is the nature of things.

From Classes of Sets to Classes of Functions

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Abstract. After some 19th century precursors, the 1968 announcement by A. Chervonenkis and V. N. Vapnik, on a kind of complexity of a class of sets, dramatically expanded the scope of laws of large numbers in probability theory. As they recognized, there were extensions to families of functions. It turned out to be possible to extend also the central limit theorem.

There have been numerous applications to statistics, not only to the original goal of learning theory. Some families of bounded rational functions of bounded degree can be used to give location vector and scatter matrices for observations from general distributions in Euclidean space which may not have finite means or variances.

Causal Inference and Statistical Learning

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Abstract. Causal inference is an intriguing field examining causal structures by testing their statistical footprints. The talk introduces the main ideas of causal inference from the point of view of machine learning, and discusses implications of underlying causal structures for popular machine learning scenarios such as covariate shift and semi-supervised learning. It argues that causal knowledge may facilitate some approaches for a given problem, and rule out others.

Combinatorial Theory of Overfitting: How Connectivity and Splitting Reduces the Local Complexity

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Abstract. Overfitting is one of the most challenging problems in Statistical Learning Theory. Classical approaches recommend to restrict complexity of the search space of classifiers. Recent approaches benefit from more refined analysis of a localized part of the search space. Combinatorial theory of overfitting is a new developing approach that gives tight data dependent bounds on the probability of overfitting. It requires detailed representation of the search space in a form of a directed acyclic graph. The size of the graph is usually enormous, however the bound can be effectively estimated by walking through its small localized part that contains best classifiers. We use such estimate as a features selection criterion to learn base classifiers in simple voting ensemble. Unlike boosting, bagging, random forests etc. which learn big ensembles of weak classifiers we learn small ensembles of strong classifiers. Particularly we use two types of base classifiers: low dimensional linear classifiers and conjunction rules. Some experimental results on UCI data sets are also reported.

About the Origins of the Vapnik Chervonenkis Lemma

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Abstract. Whereas the law of large numbers tells how to estimate the probability of a single event, the uniform law of large numbers explains how to simultaneously estimate the probabilities of an infinite family of events. The passage from the simple law to the uniform law relies on a remarkable combinatorial lemma that seems to have appeared quasi simultaneously in several countries. This short talk presents some material I have collected about the history of this earth shattering result.

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