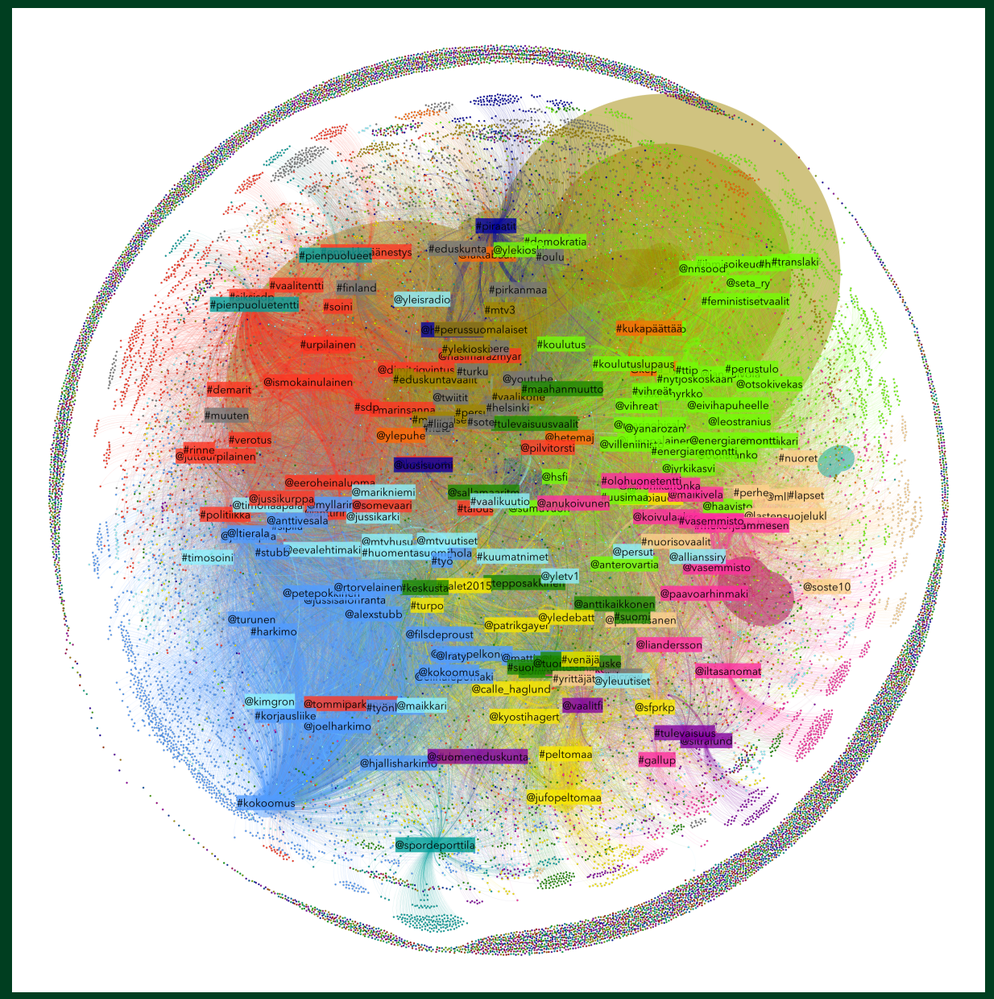
Aalto University

UNIVERSITY OF HELSINKI

HELSINKI INSTITUTE FOR INFORMATION TECHNOLOGY

Helsinki Institute for Information Technology HIIT

Annual Report 2015



Helsinki Institute for Information Technology HIIT
Tietotekniikan tutkimuslaitos HIIT
Forskningsinstitutet för Informationsteknologi HIIT

Helsinki Institute for Information Technology HIIT is a joint research institute of Aalto University and the University of Helsinki for basic and applied research on information technology. HIIT's mission is to conduct top-level research, seamlessly moving between fundamental methods and technologies to novel applications and their impact on people and society. HIIT is a strategic partnership of the two universities to take Helsinki IT to the world class and keep it there. HIIT's research is interdisciplinary, operating across departments and with industry. The current foci of research are computational modelling and data analysis, and ubiquitous ICT in the modern networked world.

HIIT groups belong to several national Centers of Excellence and co-operate with the information industry and with sciences applying information technology. HIIT works in a multidisciplinary way, with scientists from computer, natural, behavioural and social sciences, as well as from humanities and design. HIIT partners with several international and Finnish companies as well as with universities and research institutions in Europe, North America and Asia.

HIIT was founded in 1999 and now has a budget of 9 million euros, realising in total about 140 person-years of work by about 300 researchers. HIIT is located in two different sites in the Helsinki Metropolitan area: at Aalto University's Otaniemi campus and University of Helsinki's Kumpula campus. HIIT's operating principle is that it adds to other departments' activities, instead of competing with them. The institute was led by Professor Samuel Kaski until July 2015 and by Professor Petri Myllymäki from August 2015 onwards. HIIT's research is funded by Aalto University, the University of Helsinki, Tekes, the Academy of Finland, the European Union, private companies, and foundations financing Finnish hi-tech research. The research by HIIT has been assessed and deemed excellent by its Scientific Advisory Board in 2008 and 2012; in the Aalto University Research Assessment Exercise in 2009; and in the Evaluation of Research and Doctoral Training at the University of Helsinki in 2011.

www.hiit.fi

Ella Bingham, Noora Suominen de Rios (eds.)

Helsinki Institute for Information Technology HIIT

Annual Report 2015

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HELSINKI
INSTITUTE FOR
INFORMATION
TECHNOLOGY

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Unigrafia, Espoo 2016

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Lay-out: Anna Bergman, Noora Suominen de Rios

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HIIT in brief

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Total numbers	2010	2011	2012	2013	2014	2015
Funding M€	12,1	10,5	11,5	10,0	10,5	9,1
External/competitive funding	83 %	78 %	83 %	79 %	82 %	80 %
Person-years	175	135	144	154	134	138
Refereed publications	222	213	209	238	274	257

Aalto-yliopisto

HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

Review of Year 2015

Augmented research, health and knowledge work, and other IT

Helsinki Institute for Information Technology HIIT is a joint research institute of Aalto University and the University of Helsinki for basic and applied research on information technology. HIIT is a strategic partnership of the two universities to *take Helsinki IT to the world class and keep it there*.

Professor Petri Myllymäki, a HIIT group leader and programme director, started as a new Director of HIIT in August 2015. Professor Samuel Kaski's 5-year term ended in July 2015.

Two main goals of HIIT are to (1) conduct high level strategic research bridging the two universities, and (2) coordinate big common ICT issues across departments to form a common "Helsinki ICT". Year 2015 again witnessed success along both lines.

In 2015 HIIT contributed to three Centres of Excellence of the Academy of Finland: Computational Inference (COIN, overlapping with HIIT's CI programme), Inverse Problems, and Cancer Genetics.

Tekes's strategic research openings are visionary and challenging projects aiming to make serious breakthroughs that will lay the foundation for entirely new areas of business in the future. The first strategic openings were chosen in 2013 when Re:Know, Revolution of Knowledge Work, was one of the two. Re:Know is coordinated by HIIT and the partners are University of Helsinki, Aalto University and Institute for Occupational Health. In 2014, Tekes funded three new strategic openings, two of which HIIT's researchers participate in: Digital Health Revolution and Living Factories. The vision of the Digital Health Revolution initiative is that future healthcare will allow citizens to control and make use of their personal data. The goal of Living Factories is to realise the full potential of Synthetic Biology in Finland. Synthetic Biology is based on the design and engineering of new-to-nature biological systems.

Professor Hiroshi Mamitsuka from the Institute for Chemical Research, Kyoto University, Japan, started as a FiDiPro Professor funded by Tekes in the beginning of 2015.

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Finnish Centre of Excellence in Computational Inference Research

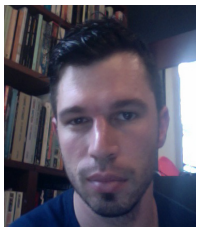
Finnish Centre of Excellence in Inverse Problems Research

The Finnish Center of Excellence in Cancer Genetics Research

Nominations

Professor Samuel Kaski, Director of HIIT until July 2015, was nominated as an Academy Professor. He develops computational methods for interactive multi-source data analysis and machine learning. The aim of the Academy of Finland's funding for an Academy Professor is to facilitate full-time scientific research for internationally leading-edge researchers. Academy Professors are expected to greatly contribute to the progress of research in their fields and develop a creative research environment.

Dr Pekka Marttinen got Academy of Finland's 5-year Academy Research Fellow funding for his research on "Enhanced learning of hierarchical structured models with biomedical applications". Similarly, Dr Simon Puglisi's 5-year Academy Research Fellow funding is for "Fast and Efficient Indexes for Highly Repetitive Data". Dr Jukka-Pekka Kauppi got Academy of Finland's 3-year Postdoctoral Research funding for his research on "Neuroscientifically motivated novel decoding methods for multichannel electromyographic and magnetoencephalographic signals" and Dr Niko Välimäki was awarded a similar position for "Variation Calling on Population Genotypes: From Data Structures to Applications".



Professor Jukka Corander was selected as a Visiting Fellow at University of Cambridge. His research during the visit will concentrate on infectious disease epidemiology and genomics. Professor Corander was also awarded the Cozzarelli Prize in biomedical sciences by PNAS, for a revolutionary discovery concerning evolutionary mechanisms in bacterial populations.

Augmented research

Augmented search, research, and knowledge work are the main themes of the HIIT-wide research initiative that is a strategic research focus of HIIT. It is a big multidisciplinary project spanning several research groups of HIIT at Aalto University and University of Helsinki. Several research groups ranging from Human-Computer Interaction to Machine Learning and Complex Systems Computation collaborates to produce cutting edge research and demonstrations that go beyond individual research papers. The initiative is described in more detail on page 31.

Collaboration

HIIT collaborates actively both within Helsinki area and internationally, and acts as a link between researchers, companies and public administration.

Collaboration in Helsinki IT

HIIT collaborates actively both within Helsinki area and internationally, and acts as a link between researchers, companies and public administration. In Helsinki area, HIIT coordinates common activities of computer science research in several ways: education, recruitments, and joint initiatives.

In doctoral education, HIIT coordinates **the Helsinki Doctoral Education Network in Information and Communications Technology (HICT)**. HICT is hosted jointly by Aalto University and the University of Helsinki, the two leading universities within this area in Finland. The network serves as a collaboration platform for doctoral education combining all the relevant subfields of computer science and information technology at Aalto University and the University of Helsinki. It involves at present 65 professors and almost 300 doctoral students, and the participating units produce altogether more than 40 new doctors each year.

HIIT also collaborates with **Institute for Molecular Medicine Finland FIMM** in recruiting PhD students to rotate between research groups at FIMM and HIIT. The collaboration is part of the Nordic EMBL Partnership for Molecular Medicine and the call is able to attract a large number of excellent doctoral candidates from all over the world.

Data Science is a big research focus for the whole HIIT, spanning over several application areas. Its objective is to provide the underlying theory and the necessary tools to cope with the current data revolution. The education in this area has been boosted by several education programmes such as the Master's Programme in Machine learning and Data mining (Madacamia) at Aalto and Data Science study profile at University of Helsinki. For interdisciplinary studies, Analytics and Data Science is a minor topic available for all MSc students at Aalto, jointly coordinated by professor Aristides Gionis from HIIT and professor Pekka Malo at Aalto BIZ. The goal of the minor is to educate students on how to become proficient in making sense of such big data, and how to apply data analysis skills on their own domain of expertise.

Recruitment is an important means of collaboration. HIIT arranges joint Helsinki IT **postdoc and senior researcher calls** together with several departments in the field of computer science at Aalto University and University of Helsinki. These joint calls leverage on and further enhance the brand of Helsinki as a hub of computer science, and attract a wide range of high-level applicants.

Aalto Digi Platform

Digi Platform is Aalto University's collaborative initiative in the field of ICT and digitalization. It is chartered to innovate, initiate and increase digitalization related cooperation broadly inside Aalto and with its industrial and academic partners. The Digi Platform facilitates and brings together Aalto's competences in this multidisciplinary area, in a bottom up manner, and increases Aalto's visibility. Expertise across Aalto is brought together to maximize the potential of IT to boost other sciences, technologies and society. The Digi Platform provides seed funding, arranges matchmaking events, acts as a collaboration platform within Aalto, and provides a "front desk" for external contacts. HIIT coordinates the Digi Platform, and University of Helsinki participates in the platform via HIIT.

International collaboration

All HIIT's activities are inherently international, mostly in a bottom-up manner. Cooperation with key international research institutes and univarrersities is active: Berkeley (ICSI and UC Berkeley), MIT, Centre for Computational Statistics and Machine Learning (CSML) at UCL, European Bioinformatics Institute EBI, Human Technology Lab (HTLab) at University of Padova, and Waseda University, to name a few.

Center for Science of Information
NSF Science and Technology Center

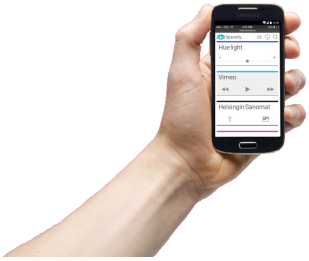
National Science Foundation

HIIT coordinates Aalto University's and University of Helsinki's strategic partnership with NSF Science and Technology Center for Science of Information (SoI). The member universities of the SoI center are Purdue (leader), Bryn Mawr, Howard, MIT, Princeton, Stanford, Texas A&M, UC Berkeley, UCSD and Urbana-Champaign. Other strategic partners in Europe are ETH (Zürich, Switzerland) and the LINCS network (Paris, France).

eit Digital

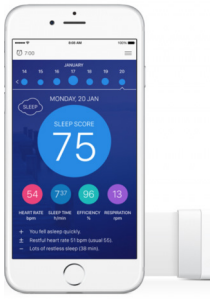
EIT Digital is an European initiative intended to turn Europe into a global leader in ICT innovation. It aims to fulfill this mission by establishing a new type of partnership between leading companies, research centres, and universities in Europe. One of the 5 nodes is Helsinki. Several HIIT researchers have research projects with EIT Digital.

HIIT's researcers are active in organizing high-profile international conferences and workshops: the most recent ones are International Conference on Computational Creativity ICCC 2015 and 4th International Workshop on Symbiotic Interaction.



Societal impact

HIIT aims to boost the competitiveness of the Finnish information industry and information society in the long run by linking scientific research with the long-term high-risk research and development of the information industry, and by contributing to the development of the information society. HIIT both anticipates developments of the information society and influences them. New technologies developed at HIIT are taken into use at the ICT sector or other fields in the commercial and public sector.



HIIT's researchers and alumni establish approximately one startup company per year. The newest one is Spaceify, a startup to webify spaces. The aim of Spaceify is to commercialise solutions that provide immediate interaction with smart spaces through web technologies. The core of the solution is a client-edge-server ecosystem that seamlessly integrates physical spaces with the web. Spaceify can give web apps controlled access to resources such as big screens, sensors and lighting in the space. The founding of Spaceify Oy is an example of long-term strategic research resulting in an impact beyond academic results.

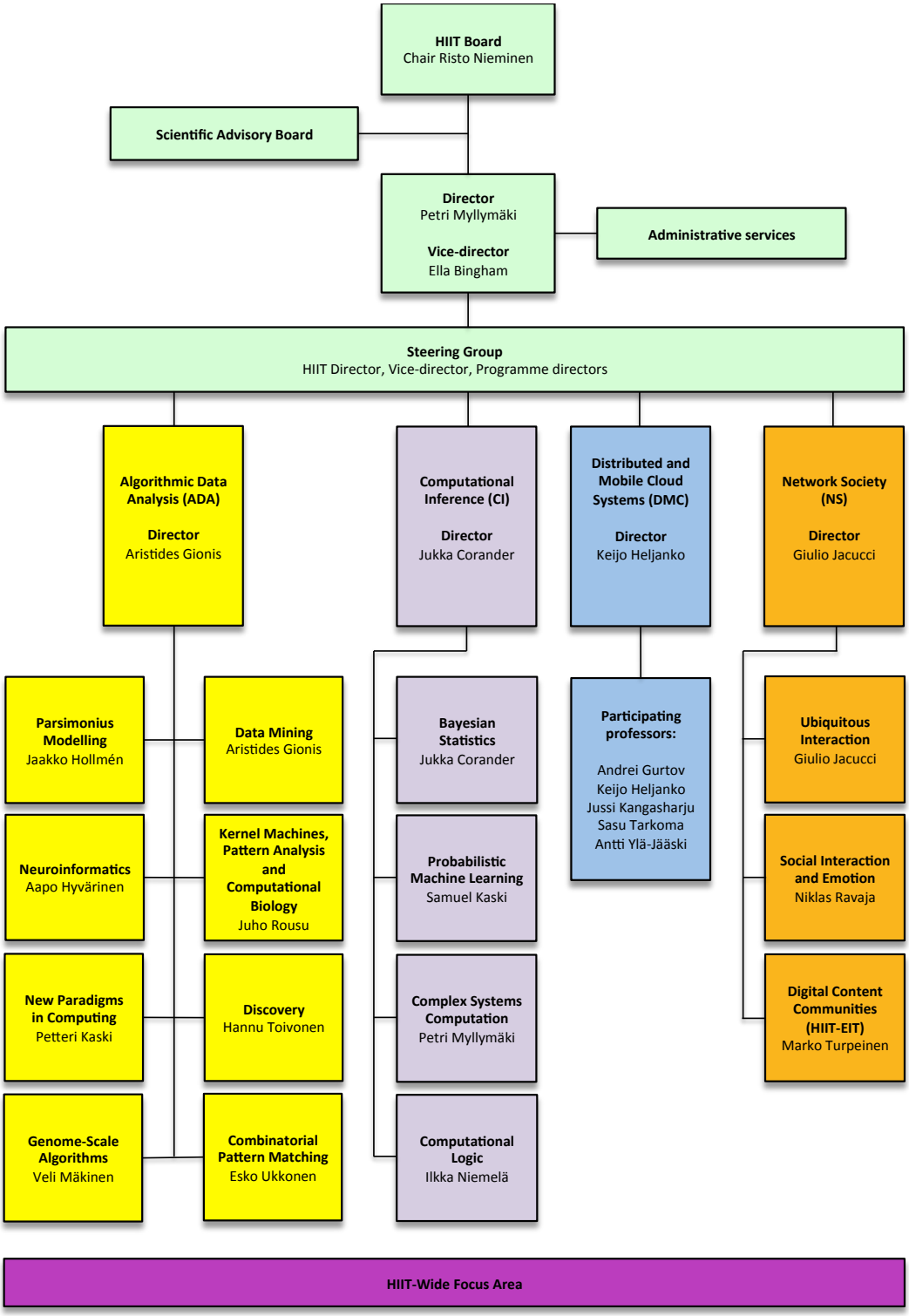
The sleep monitor firm Beddit uses a sleep analysis software developed in the PhD work of Joonas Paalasmaa of HIIT.

HIIT researchers have been active in issues related to public policy having the profile of a vocal and visible participant in the public debate related to various important themes of information society, especially the discussion on emerging social forms of media use, immaterial rights, privacy and trust in the network society. MyData is a human-centric approach to the managing and processing of personal information. It is based on the right of individuals to access the data collected about them. The core idea is that individuals should be in control of their own data. The MyData approach aims at strengthening digital human rights while opening new opportunities for businesses to develop innovative personal data based services built on mutual trust. HIIT researchers Kai Kuikkaniemi and Antti Poikola are key figures behind MyData in Finland.

Views for 2016

The research programmes of HIIT will be renewed in 2016. The new programmes will be challenge-oriented, scientifically top-level, potentially high-impact with respect to HIIT's mission, interdisciplinary, and fixed term. Administratively all HIIT's activities at Aalto University merge with the Computer Science department of the School of Science at Aalto University as of 1 January 2016. This will not restrict HIIT's scientific activities, and HIIT researchers can also be affiliated with other departments at Aalto University.

Helsinki Institute for Information Technology

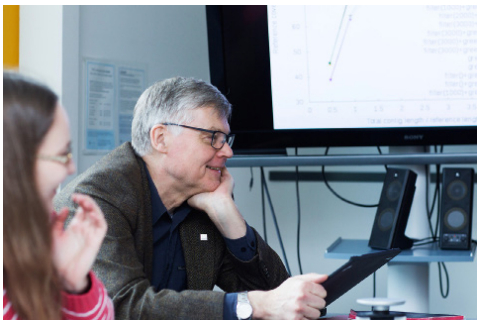


Research

Algorithmic Data Analysis (ADA) Programme

The mission of the Algorithmic Data Analysis (ADA) research programme at HIIT is to develop useful algorithmic data analysis methods for other sciences and for industry. The work involves both basic research in computer science and applied work on problems arising from applications. The research focuses on the algorithmic and modeling problems of combinatorial pattern matching, data mining, and machine learning. The work is strongly interdisciplinary. Developing new concepts and algorithms is an iterative process consisting of interacting extensively with the application experts, formulating computational concepts, analyzing the properties of the concepts, designing algorithms and analyzing their performance, implementing and experimenting with the algorithms, and applying the results in practice. The main application areas of ADA are in biology, medicine, environmental studies, creativity, social networks, and neuroscience.

Combinatorial Pattern Matching, Professor Esko Ukkonen



The combinatorial pattern-matching group develops combinatorial algorithms and probabilistic modeling techniques for pattern search and synthesis problems in sequential and higher-dimensional data. The team is interested in the basic research of the theoretical aspects of the area as well as in various applications such as genome structure, gene regulation, and information retrieval.

Key publications:

- Jouni Kvist, Anniina L. K. Mattila, Panu Somervuo, Virpi Ahola, Patrik Koskinen, Lars Paulin, Leena Salmela, Toby Fountain, Pasi Rastas, Annukka Ruokolainen, Minna Taipale, Liisa Holm, Petri Auvinen, Rainer Lehtonen, Mikko J. Frilander, and Ilkka Hanski. Flight-induced changes in gene expression in the Glanville fritillary butterfly. Molecular Ecology, 24(19):4886–4900, 10 2015.
- Leena Salmela, Kristoffer Sahlin, Veli Mäkinen, and Alexandru I. Tomescu. Gap filling as exact path length problem. In Teresa M. Przytycka, editor, Research in Computational Molecular Biology: 19th Annual International Conference, RECOMB 2015, Warsaw, Poland, April 12-15, 2015, Proceedings, volume 9029 of Lecture Notes in Bioinformatics, pages 281–292, 2015.

Data Mining,
Professor Aristides Gionis

The data-mining group focuses on developing novel methods to extract knowledge from data, designing algorithms to summarize large volumes of data efficiently and effectively, and exploring new ways of using the extracted information. Specific areas of interest include: pattern discovery, clustering and outlier detection, graph mining, social-network analysis, analysis of information networks and social-network dynamics, and analysis of smart-city sensor data.

Key publications:

- Francesco Bonchi, Aristides Gionis, Francesco Gullo, Charalampos E. Tsourakakis, and Antti Ukkonen. Chromatic correlation clustering. ACM Transactions on Knowledge Discovery from Data, 9(4):000034/1–24, 2015.
- Ehsan Amid, Aristides Gionis, and Antti Ukkonen. A kernel-learning approach to semi-supervised clustering with relative distance comparisons. Machine Learning and Knowledge Discovery in Databases: European Conference, ECML PKDD 2015, Porto, Portugal, September 7-11, 2015, Proceedings, Part I. Springer, 2015.
- Kiran Garimella, Gianmarco De Francisci Morales, Aristides Gionis, and Mauro Sozio. Scalable facility location for massive graphs on Pregel-like systems. In 24th ACM International Conference on Information and Knowledge Management (CIKM 2015), pages 273–282, October 2015.
- Aristides Gionis, Michael Mathioudakis, and Antti Ukkonen. Bump hunting in the dark: Local discrepancy maximization on graphs. In 31st IEEE International Conference on Data engineering (ICDE), 2015.
- Orestis Kostakis and Aristides Gionis. Subsequence search in event-interval sequences. In 38th International ACM SIGIR Conference on Research and Development in Information Retrieval, pages 851–854, New York, NY, USA, August 2015.
- Rohit Kumar, Toon Calders, Aristides Gionis, and Nikolaj Tatti. Maintaining sliding-window neighborhood profiles in interaction networks. Machine Learning and Knowledge Discovery in Databases: European Conference, ECML PKDD 2015, Porto, Portugal, September 7-11, 2015, Proceedings, Part II, pages 719-735, Springer, 2015.
- Eric Malmi, Arno Solin, and Aristides Gionis. The blind leading the blind: Network-based location estimation under uncertainty. Machine Learning and Knowledge Discovery in Databases: European Conference, ECML PKDD 2015, Porto, Portugal, September 7-11, 2015, Proceedings, Part II, pages 406–421. Springer, 2015.
- Charalampos Mavroforakis, Michael Mathioudakis, and Aristides Gionis. Absorbing random-walk centrality: Theory and algorithms. In IEEE International Conference on Data Mining (ICDM), 2015.
- Nikolaj Tatti and Aristides Gionis. Density-friendly graph decomposition. In Proceedings of the 24th International Conference on World Wide Web (WWW 2015), page 1099, 2015.

Discovery Group: Data Mining and Computational Creativity, Professor Hannu Toivonen

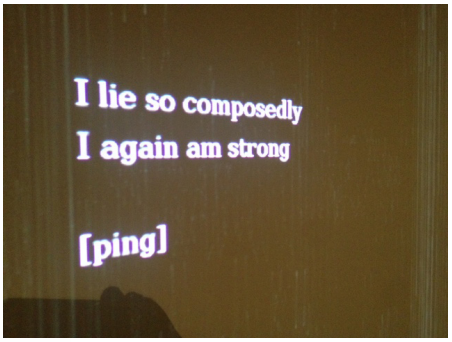
The Discovery research group develops novel methods and tools for data mining and computational creativity. Our focus is on algorithmic methods for discovering links and patterns in data and on their use in creative systems.

In data mining and graph mining we focus on analysis and exploration methods for text documents and weighted graphs. We identify relevant computational problems, develop new concepts and algorithms, and apply them.

A more recent focus area is computational creativity, interesting on its own right but also as an application area for data mining methods. We work on verbal creativity, i.e., computational poetry and humour, and also on automatic composition of music. We are developing novel methods that minimize the need for manually coded or language-specific knowledge.

Key publications:

- Joonas Paalasmaa, Hannu Toivonen, and Markku Partinen. Adaptive heartbeat modeling for beat-to-beat heart rate measurement in ballistocardiograms. IEEE Journal of Biomedical and Health Informatics, 19(6):1945–1952, 11 2015.
- Hannu Toivonen and Oskar Gross. Data mining and machine learning in computational creativity. Wiley Interdisciplinary Reviews. Data Mining and Knowledge Discovery, 5(6):265–275, 2015.
- Anna Kantosalo, Jukka Toivanen, and Hannu Toivonen. Interaction evaluation for human-computer co-creativity: A case study. In Hannu Toivonen, Simon Colton, Michael Cook, and Dan Ventura, editors, Sixth International Conference on Computational Creativity (ICCC 2015), pages 276–283, 2015.
- Ping Xiao and Simo Matias Linkola. Vismantic: Meaning-making with images. In Hannu Toivonen, Simon Colton, Michael Cook, and Dan Ventura, editors, Sixth International Conference on Computational Creativity (ICCC 2015), pages 158–165, 6 2015.



Neuroinformatics, Professor Aapo Hyvärinen

Neuroinformatics is widely defined as the cross-fertilization of information-processing and mathematical sciences on the one hand, and neural and cognitive sciences on the other.

Our group works on different aspects of neuroinformatics related to machine learning. We model the visual system in the brain by analyzing the statistical structure of the natural input images. We apply machine learning models on neuroimaging data, in particular MEG. We also develop the relevant theory of statistical machine learning, typically unsupervised.

Key publications:

- Aleksandra Herbec, Jukka-Pekka Kauppi, Corinne Jola, Jussi Tohka, and Frank E. Pollick. Differences in fMRI intersubject correlation while viewing unedited and edited videos of dance performance. Cortex, 71:341–348, 10 2015.
- Haruo Hosoya and Aapo Hyvärinen. A hierarchical statistical model of natural images explains tuning properties in V2. Journal of Neuroscience, 35(29):10412–10428, 2015.
- Jukka-Pekka Kauppi, Janne Hahne, Klaus-Robert Müller, and Aapo Hyvärinen. Three-way analysis of spectrospatial electromyography data: Classification and interpretation. PLoS One, 10(6), 6 2015.
- Aapo Hyvärinen. A unified probabilistic model for independent and principal component analysis. In Ella Bingham, Samuel Kaski, Jorma Laaksonen, and Jouko Lampinen, editors, Advances in Independent Component Analysis and Learning Machines, pages 75–82. Elsevier, 2015.

Parsimonious Modeling, Dr. Jaakko Hollmén

The research group Parsimonious Modelling develops novel computational data analysis methods and applies these methods on two application fields: cancer genomics and environmental informatics. Parsimonious modeling aims at simple, compact, or sparse models as a result of learning from data in the presence of very little or no a priori information about the modeled problem. Simplicity of the models facilitates understanding of the problem domain by humans.

Both application fields present similar challenges to the data analysis problems: the high dimensionality of observed data and the presence of moderate or large noise levels are both factors that bear fundamental problems for any data analysis. Seeking new areas of application and interfacing the newest application domains with lots of novel types of generated data helps in finding new, unsolved settings of problems.

Key publications:

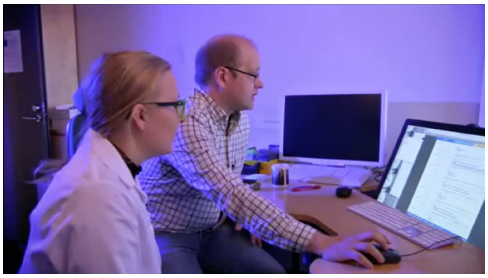
- Prem Raj Adhikari and Jaakko Hollmen. Fast progressive training of mixture models for model selection. Journal of Intelligent Information Systems, 44(2):223–241, 2015.
- Luca Martino, Jesse Read, and David Luengo. Independent doubly adaptive rejection metropolis sampling within Gibbs sampling. IEEE Transactions on Signal Processing, 63(12):3123–3138, 2015.
- Indre Zliobaite, Albert Bifet, Jesse Read, Bernhard Pfahringer, and Geoff Holmes. Evaluation methods and decision theory for classification of streaming data with temporal dependence. Machine Learning, 98(3):455–482, 2015.
- Indre Zliobaite and Jaakko Hollmen. Optimizing regression models for data streams with missing values. Machine Learning, 99(1):47–73, 2015.
- Albert Bifet, Gianmarco De Francisci Morales, Jesse Read, Bernhard Pfahringer, and Geoff Holmes. Efficient online evaluation of big data stream classifiers. In 21st ACM SIGKDD Conference on Knowledge Discovery and Data Mining (KDD-2015), pages 59–68. AAAI Press, August 2015.
- Jesse Read, Albert Bifet, and Fernando Perez-Cruz. Deep learning in partially-labeled data streams. In 30th ACM Symposium on Applied Computing (SAC 2015), April 2015.
- Olli-Pekka Rinta-Koski, Jaakko Hollmén, Markus Leskinen, and Sture Andersson. Variation in oxygen saturation measurements in very low birth weight infants. In Fillia Makedon, editor, Proceedings of the 8th ACM International Conference on PErvasive Technologies Related to Assistive Environments, New York, NY, USA, July 2015. ACM.

Kernel Machines, Pattern Analysis and Computational Biology, Professor Juho Rousu

The group develops machine learning methods, models and tools for data science, in particular computational metabolomics. The methodological backbone of the group is formed by kernel methods and regularized learning. The group focusses in learning with multiple and structured targets, multiple views and ensembles. Machine learning applications of interest include metabolite identification, metabolic network reconstruction and pathway analysis, chemogenomics as well as biomarker discovery.

Key publications:

- Anna Cichonska, Juho Rousu, and Tero Aittokallio. Identification of drug candidates and repurposing opportunities through compound-target interaction networks. Expert Opinion on Drug Discovery, 10(12):1333–1345, 2015.
- Kai Dührkop, Huibin Shen, Marvin Meusel, Juho Rousu, and Sebastian Böcker. Searching molecular structure databases with tandem mass spectra using CSI:FingerID. Proceedings of the National Academy of Sciences. 112(41):12580–12585, 2015.
- Hongyu Su. Multilabel Classification through Structured Output Learning - Methods and Applications. PhD thesis, Aalto University, 2015.
- Hongyu Su and Juho Rousu. Multilabel classification through random graph ensembles. Machine Learning, 99(2):231–256, 2015.
- Viivi Uurtio, Malin Bomberg, Kristian Nybo, Merja Itävaara, and Juho Rousu. Canonical correlation methods for exploring microbe-environment interactions in deep subsurface. In Discovery Science. 18th International Conference, DS 2015, Banff, AB, Canada, October 4-6, 2015. Proceedings, LNCS 9356, pages 299–307. Springer International Publishing, October 2015.



Genome-Scale Algorithms, Professor Veli Mäkinen

We develop algorithms and data structures for the analysis of genome-scale data. Such data is abundant due to modern molecular biology measurement techniques like high-throughput sequencing. We are especially interested in applications of compressed data structures, that make it possible to analyse the often highly redundant data within the space of their information content. We also study other scalability aspects like distributed computation/storage around genome-scale data.

Key publications:

- Diego Arroyuelo, Francisco Claude, Sebastian Maneth, Veli Mäkinen, Gonzalo Navarro, Kim Nguyen, Jouni Sirén, and Niko Välimäki. Fast in-memory XPath search using compressed indexes. Software: Practice & Experience, 45(3):399–434, 3 2015.
- Djamal Belazzougui. Improved space-time tradeoffs for approximate full-text indexing with one edit error. Algorithmica, 72(3):791–817, 7 2015.
- Djamal Belazzougui and Gonzalo Navarro. Optimal lower and upper bounds for representing sequences. ACM Transactions on Algorithms, 11(4), 2015.
- Travis Gagie, Pawel Gawrychowski, and Simon J. Puglisi. Approximate pattern matching in LZ77-compressed texts. Journal of Discrete Algorithms, 32:64–68, 2015.
- Alexandru I. Tomescu, Travis Gagie, Alexandru Popa, Romeo Rizzi, Anna Kuosmanen, and Veli Mäkinen. Explaining a weighted DAG with few paths for solving genome-guided multi-assembly. IEEE/ACM Transactions on Computational Biology and Bioinformatics, 12(6):1345–1354, 12 2015.
- Karen E. van Rens, Veli Mäkinen, and Alexandru I. Tomescu. SNV-PPILP: refined SNV calling for tumor data using perfect phylogenies and ILP. Bioinformatics, 31(7):1133– 1135, 4 2015.
- Roland Wittler, Tobias Marschall, Alexander Schönhuth, and Veli Mäkinen. Repeat- and error-aware comparison of deletions. Bioinformatics, 31(18):2947–2954, 9 2015.
- Djamal Belazzougui, Veli Mäkinen, and Daniel Valenzuela. Compressed suffix array. In Ming-Yang Kao, editor, Encyclopedia of Algorithms. Springer, 2015.
- Travis Gagie. Rank and select operations on sequences. In Ming-Yang Kao , editor, Encyclopedia of Algorithms. Springer, 2015.
- Veli Mäkinen, Djamal Belazzougui, Fabio Cunial, and Alexandru Ioan Tomescu. Genome-Scale Algorithm Design: Biological Sequence Analysis in the Era of High-Throughput Sequencing. Cambrigde University Press, United Kingdom, 5 2015.

New Paradigms in Computing, Professor Petteri Kaski

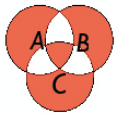
The group performs basic research at the intersection of core computer science (algorithm design and analysis) and discrete mathematics, with an emphasis towards novel techniques and less studied models of computation. We invest substantial effort to high-risk, high-yield research problems of relatively broad theoretical interest, selected on both problem and method driven basis. The current research themes of the group are threefold. (1) Exploring the interplay between algebraic, combinatorial, and geometric techniques in the design of exact deterministic algorithms. For example, many combinatorial problems can be cast in algebraic form, whereby a nontrivial algebraic algorithm yields a more efficient solution compared with direct combinatorial tools. (2) Restricted models of computation and tradeoffs in resources and/or objectives. (3) While we are a theory group, we occasionally engage in practical algorithm implementation. Examples include attacks on combinatorial classification problems and applications in computational geometry.

Key publications:

- Michael A. Bender, Sándor P. Fekete, Alexander Kröller, Vincenzo Liberatore, Joseph S. B. Mitchell, Valentin Polishchuk, and Jukka Suomela. The minimum backlog problem. Theoretical Computer Science, (605):51–61, 2015.
- Andreas Björklund, Thore Husfeldt, Petteri Kaski, Mikko Koivisto, Jesper Nederlof, and Pekka Parviainen. Fast Zeta transforms for lattices with few irreducibles. ACM Transactions on Algorithms, 12(1):4, 2015.
- Ho-Lin Chen, David Doty, and Shinnosuke Seki. Program size and temperature in self-assembly. Algorithmica, 72(3):884–899, 2015.
- Alon Efrat, Sándor P. Fekete, Joseph S. B. Mitchell, Valentin Polishchuk, and Jukka Suomela. Improved approximation algorithms for relay placement. ACM Transactions on Algorithms, 12(2):28 p., 2015.
- Serge Gaspers, Mikko Koivisto, Mathieu Liedloff, Sebastian Ordyniak, and Stefan Szeider. On finding optimal polytrees. Theoretical Computer Science, 592(C):49–58, 2015.
- Lauri Hella, Matti Järvisalo, Antti Kuusisto, Juhana Laurinharju, Tuomo Lempiäinen, Kerkko Luosto, Jukka Suomela, and Jonni Virtema. Weak models of distributed computing, with connections to modal logic. Distributed computing, 28(1):31–53, 2015.
- Petteri Kaski, Patric R.J. Östergård, and Alexandru Popa. Enumeration of Steiner triple systems with subsystems. Mathematics of Computation, 84(-):3051–3067, 2015.
- Keren Censor-Hillel, Petteri Kaski, Janne H. Korhonen, Christoph Lenzen, Ami Paz, and Jukka Suomela. Algebraic methods in the congested clique. In Proc. ACM PODC, pages 143–152, 2015.
- Juho-Kustaa Kangas, Teppo Niinimäki, and Mikko Koivisto. Averaging of decomposable graphs by dynamic programming and sampling. In Proc. UAI, pages 415–424, 2015.
- Christoph Lenzen, Joel Rybicki, and Jukka Suomela. Towards optimal synchronous counting. In Proc. ACM PODC, pages 441–450, July 2015.

$$\Delta(f,g,h) = \sum_{\substack{A,B,C\in\binom{[n]}{k/3} \\ A\cap B=\emptyset \\ A\cap C=\emptyset \\ B\cap C=\emptyset}} f(A)g(B)h(C) = x_k$$

$$x_j = \sum_{\substack{A,B,C\in\binom{[n]}{k/3} \\ |A\oplus B\oplus C|=j}} f(A)g(B)h(C)$$



$$j = 0, 1, \ldots, k$$

$$X \oplus Y = (X \setminus Y) \cup (Y \setminus X)$$

$$j \equiv k \pmod 2$$

Computational Inference (CI) Programme

The four groups of the CI programme are all members of the Finnish Centre of Excellence in Computational Inference Research (COIN), and the objectives of the programme are closely intertwined with those of COIN.

The main objective of CI is to develop methods for transforming the data produced by the current data revolution into useful information. The key methodology for achieving this goal is statistical and computational inference based on the data. The emphasis is on large data collections and computationally demanding modelling and inference algorithms. Our mission is to push the boundary towards both more complex problems, requiring more structured data models, and towards extremely rapid inference. We address a set of carefully chosen interdisciplinary “grand challenge” -level problems with high societal impact where solving the data intensive problems requires novel methodologies that can only result from combining the expertise of separate subfields

Our mission brings up four partially overlapping methodological focus areas: Learning of massive data-driven models; Learning from multiple sources; Statistical inference in highly structured stochastic models; and Extreme inference engine.

In applied research our work is also motivated by the big data and ubiquitous computing vision, where adaptivity, context-awareness and personalisation are key enablers. We see that our four methodological research areas support strongly each other, and they all address from a different perspective the key technological problems we face in our future “big data” information society. In our applied research we link our strong basic research work in machine learning and constraint reasoning to well-motivated applied research activities involving prototype applications and real-world deployments

Aalto University UNIVERSITY OF HELSINKI COIN Finnish Centre of Excellence in Computational Inference Research

Probabilistic Machine Learning, Professor Samuel Kaski

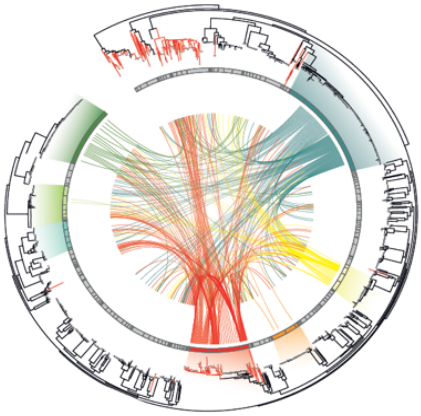
We develop new methods for probabilistic modeling, Bayesian inference and machine learning. Our current focuses are in particular learning from multiple data sources, Bayesian model assessment and selection, approximate inference and information visualization. Our primary application areas are digital health and biology, neuroscience and user interaction.

Key publications:

- James Hensman, Panagiotis Papastamoulis, Peter Glaus, Antti Honkela, and Magnus Rattray. Fast and accurate approximate inference of transcript expression from RNA-seq data. Bioinformatics, 31(24):3881–3889, 12 2015.
- Antti Honkela, Jaakko Peltonen, Hande Topa, Iryna Charapitsa, Filomena Matarese, Korbinian Grote, Hendrik G. Stunnenberg, George Reid, Neil D. Lawrence, and Magnus Rattray. Genome-wide modeling of transcription kinetics reveals patterns of RNA production delays. PNAS, 112(42):13115–13120, 10 2015.
- Jukka-Pekka Kauppi, Melih Kandemir, Veli-Matti Saarinen, Lotta Hirvenkari, Lauri Parkkonen, Arto Klami, Riitta Hari, and Samuel Kaski. Towards brain-activity-controlled information retrieval: Decoding image relevance from MEG signals. NeuroImage, 112(1):288–298, 2015.
- Arto Klami, Seppo Virtanen, Eemeli Leppäaho, and Samuel Kaski. Group factor analysis. IEEE Transactions on Neural Networks and Learning Systems, 26(9):2136– 2147, 2015.
- Tuukka Ruotsalo, Giulio Jacucci, Petri Myllymäki, and Samuel Kaski. Interactive intent modeling: Information discovery beyond search. Communications of the ACM, 58(1):86–92, 2015.
- Hande Topa, Àgnes Jònàs, Robert Kofler, Carolin Kosiol, and Antti Honkela. Gaussian process test for high-throughput sequencing time series: application to experimental evolution. Bioinformatics, 31(11):1762–1770, 2015.
- Zhirong Yang, Jaakko Peltonen, and Samuel Kaski. Majorization-minimization for manifold embedding. In The 18th International Conference on Artificial Intelligence and Statistics (AISTATS'15), pages 1088–1097, USA, May 2015.
- Dario Gasbarra , Elja Arjas, Aki Vehtari, Rémy Slama, and Niels Keiding. The current duration design for estimating the time to pregnancy distribution: a nonparametric Bayesian perspective. In Lifetime Data Analysis, volume 21, Issue 4, pp 594-625, 2015.

Bayesian Statistics, Professor Jukka Corander

We do research on theoretical and applied machine learning, biometry, bioinformatics and forensic statistics. Some specific areas of interest are clustering and statistical inference in highly structured stochastic models. Our main application area is computational biology, in particular models for evolution and transmission of bacteria and viruses. These findings have been enabled by our better scalable Bayesian inference methods for the analysis of bacterial whole-genome data that are several orders of magnitude faster than recent other methods based on standard Bayesian computation.



Key publications:

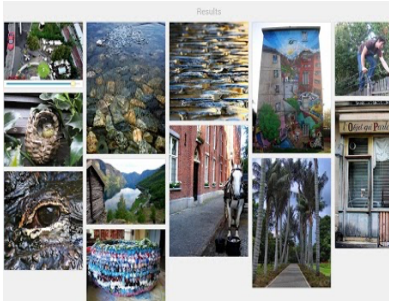
- Johan Pensar, Henrik Nyman, Jarno Lintusaari, Jukka Corander. The role of local partial independence in learning of Bayesian networks. International Journal of Approximate Reasoning, doi:10.1016/j.ijar.2015.11.008, 2015.
- Paul Blomstedt, Jing Tang, Jie Xiong, Christian Granlund, and Jukka Corander. A Bayesian predictive model for clustering data of mixed discrete and continuous type. IEEE Transactions on Pattern Analysis and Machine Intelligence, 37(3):489–498, 2015.
- Lucy Weinert, Roy Chaudhuri, Jinhong Wang, Sarah Peters, Jukka Corander, Thibaut Jombart, Abiyad Baig, Kate Howell, Minna Vehkala, Niko Välimäki, David Harris, Bich Chieu Tran Thi, Chau Nguyen Van Vinh, James Campbell, Constance Schultsz, Julian Parkhill, Stephen Bentley, Paul Langford, Andrew Rycroft, Brendan Wren, Jeremy Farrar, Stephen Baker, Ngo Hoa, Matthew Holden, Alexander Tucker, and Duncan Maskell. Genomic signatures of human and animal disease in the zoonotic pathogen Streptococcus suis. Nature Communications, doi:10.1038/ncomms7740, 2015.
- Luca Martino, Jesse Read, and David Luengo. Independent doubly adaptive rejection metropolis sampling within Gibbs sampling. IEEE Transactions on Signal Processing, 63(12):3123–3138, 2015.
- Luca Martino, Víctor Elvira, David Luengo, and Jukka Corander. An Adaptive Population Importance Sampler: Learning from Uncertainty. IEEE Transactions on Signal Processing, doi: 10.1109/TSP.2015.2440215, 2015.
- Pekka Marttinen, Nicholas J. Croucher, Michael U. Gutmann, Jukka Corander, and William P. Hanage. Recombination produces coherent bacterial species clusters in both core and accessory genomes. Microbial Genomics, (1):5, 2015.
- Tomi Janhunen, Martin Gebser, Jussi Rintanen, Henrik Nyman, Johan Pensar, Jukka Corander. Learning Discrete Decomposable Graphical Models via Constraint Optimization. Statistics and Computing, DOI: 10.1007/s11222-015-9611-4, 2015.

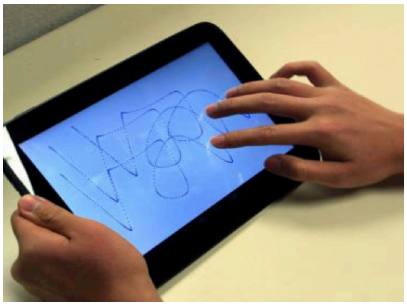
Complex Systems Computation (CoSCo), Professor Petri Myllymäki

The CoSCo research group investigates computational problems related to complex systems, focusing on prediction and modeling tasks. The basic research areas addressed include machine learning, probabilistic modeling and data analysis, information theoretical approaches to inference and constraint reasoning and optimization. Central themes in the applied research include methods for analyzing and visualizing multidimensional and multimodal Big Data, intelligent information retrieval and context-awareness for ubiquitous computing.

Key publications:

- Kazuho Watanabe and Teemu Roos. Achievability of asymptotic minimax regret by horizon-dependent and horizon-independent strategies. Journal of Machine Learning Research, 16:2357 2375, 11 2015.
- Ralf Eggeling, Teemu Roos, Petri Myllymäki, and Ivo Grosse. Inferring intra-motif dependencies of DNA binding sites from ChIP-seq data. BMC Bioinformatics, 16, 11 2015.
- Arto Klami, Seppo Virtanen, Eemeli Leppäaho, and Samuel Kaski. Group factor analysis. IEEE Transactions on Neural Networks and Learning Systems, 26(9):2136– 2147, 2015.
- Arto Klami, Abhishek Tripathi, Jalmar Sirola, Lauri Väre, and Frederic Roulland. Latent feature regression for multivariate count data. In Proceedings of AISTATS 2015, pages 462–470, 2015.
- Brandon Malone, Matti Järvisalo, and Petri Myllymäki. Impact of learning strategies on the quality of Bayesian networks: An empirical evaluation. In Proceedings of UAI 2015, pages 562–571, 2015.
- Antti Hyttinen, Frederick Eberhardt, and Matti Järvisalo. Do-calculus when the true graph is unknown. In Proceedings of UAI 2015, pages 395–404, 2015.
- Dag Sonntag, Matti Järvisalo, Jose Pena, and Antti Hyttinen. Learning optimal chain graphs with answer set programming. In Proceedings of UAI, pages 822–831, 2015.
- Adrian Balint, Anton Belov, Matti Järvisalo, and Carsten Sinz. Overview and analysis of the SAT challenge 2012 solver competition. Artificial Intelligence, 223:120–155, 2015.
- Marijn Heule, Matti Järvisalo, Florian Lonsing, Martina Seidl, and Armin Biere. Clause elimination for SAT and QSAT. Journal of Artificial Intelligence Research, 53:127–168, 2015.



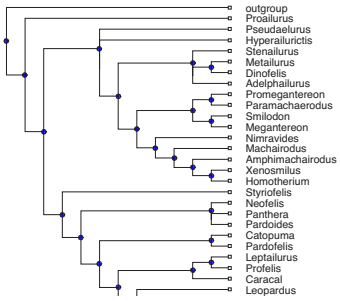


Computational Logic, Professor Ilkka Niemelä

The group develops automated reasoning techniques for solving challenging computational problems in engineering and science. The current focus is on efficient computational methods for solving large constraint satisfaction problems formally represented as Boolean satisfiability (SAT) problems or their generalizations, or expressed in terms of rule-based constraints used in answer-set programming (ASP). The group has a strong track record in research on verification and testing of automation systems and software, as well as applying formal methods in the analysis of distributed systems.

In 2015, our research on ASP concentrated on various aspects of the paradigm. As regards aggregate functions used in ASP, we developed a polynomial, faithful, and modular translation into monotonic aggregates that lend themselves for efficient implementation with contemporary solver technology. In addition, the input language of the state-of-the-art ASP grounder Gringo was formally extended by a number of constructs such as intervals, pooling, and aggregates. We also developed new techniques for ASP solving in dynamic settings where new domain elements are gradually incorporated into a problem description. A variety of application problems were studied, including the inference of phylogenetic supertrees from partial, mutually conflicting phylogenies. A real-world dataset concerning the family of cats (Felidae) was used for benchmarking.

In the area of constraint-based planning and scheduling, we investigated the use of SAT modulo theories (SMT) framework in timed systems planning. The research has developed new modeling languages, discretization methods, and encodings of timed planning systems in SMT, leading to dramatic performance improvements over earlier SMT-based methods, and to far better plan quality than is possible with leading methods that do not take into account time information during the search phase, but handle action scheduling and selection separately.



Key publications:

- Mario Alviano, Wolfgang Faber, and Martin Gebser. Rewriting Recursive Aggregates in Answer Set Programming: Back to Monotonicity. Theory and Practice of Logic Programming, 15 (4-5), 559-573, 2015.
- Martin Gebser, Amelia Harrison, Roland Kaminski, Vladimir Lifschitz, and Torsten Schaub. Abstract Gringo. Theory and Practice of Logic Programming, 15 (4-5), 449-463, 2015.
- Martin Gebser, Tomi Janhunen, Holger Jost, Roland Kaminski, and Torsten Schaub: ASP Solving for Expanding Universes. International Conference on Logic Programming and Nonmonotonic Reasoning (LPNMR), 354-367, 2015.
- Laura Koponen, Emilia Oikarinen, Tomi Janhunen, and Laura Säilä. Optimizing Phylogenetic Supertrees Using Answer Set Programming. Theory and Practice of Logic Programming, 15 (4-5), 604-619, 2015.
- Jussi Rintanen: Discretization of Temporal Models with Application to Planning with SMT. AAAI Conference on Artificial Intelligence, 3349-3355, 2015.
- Jussi Rintanen: Models of Action Concurrency in Temporal Planning. International Joint Conference on Artificial Intelligence (IJCAI), 1659-1665, 2015.

Distributed and Mobile Cloud Systems (DMC)

The focus of the programme is to bridge the gap between mobile devices and the cloud based server backend systems into a single seamless distributed and mobile computing platform. The main motivation behind this is that mobile devices are by their very nature very resource constrained in available battery power, CPU, memory, network, as well as storage capacity compared to the server hardware available in the cloud backend systems. Thus mobile devices need to be tightly integrated to the cloud backend systems in order to do computational tasks that are too heavy for them. However, this basic setup is not yet sufficient for highly interactive applications. The wide area network (WAN) communication latencies between the mobile device and the possibly quite physically remote cloud backend can often be too large for interactive mobile applications, e.g., for interactive augmented reality applications such as Google Glass, as well as computationally intensive mobile intelligent information access applications. Therefore, sometimes an additional layer of computing called cloudlets is called for, that is a collection of local cloud servers that acts as local computing service for mobile devices in its own network neighborhood area. This idea is also known as cyber foraging in the literature.

The research programme operates via close collaboration of the groups of Professors Andrei Gurtov, Keijo Heljanko, Jussi Kangasharju, Sasu Tarkoma and Antti Ylä-Jääski.





Key publications of the DMC programme:

- Ijaz Ahmad, Suneth Namal, Mika Ylianttila, and Andrei Gurtov. Security in software defined networks: A survey. IEEE Communications Surveys and Tutorials, 17(4):2317–2346, 2015.
- Suzan Bayhan, Esa Hyytiä, Jussi Kangasharju, and Jörg Ott. Analysis of hop limit in opportunistic networks by static and time-aggregated graphs. In 2015 IEEE International Conference on Communications (ICC), pages 3288–3292, 6 2015.
- Sourav Bhattacharya, Henrik Blunck, Mikkel Baun Kjaergaard, and Petteri Nurmi. Robust and energy-efficient trajectory tracking for mobile devices. IEEE Transactions on Mobile Computing, 14(2):430–443, 2 2015.
- Huber Flores, Pan Hui, Sasu Tarkoma, Yong Li, Satish Srirama, and Rajkumar Buyya. Mobile code offloading: From concept to practice and beyond. IEEE Communications Magazine, 53(3):80– 88, 2015.
- Mohammad A. Hoque, Matti Siekkinen, Jukka K. Nurminen, Mika Aalto, and Sasu Tarkoma. Mobile multimedia streaming techniques: QoE and energy saving perspective. Pervasive and Mobile Computing, 16(Part A):96 114, 2015.
- Mohammad A. Hoque, Matti Siekkinen, Kashif Khan, Yu Xiao, and Sasu Tarkoma. Modeling, profiling, and debugging the energy consumption of mobile devices. ACM Computing Surveys, 48(3), 2015.
- Jussi Lahtinen, Tuomas Kuismin, and Keijo Heljanko. Verifying large modular systems using iterative abstraction refinement. Reliability Engineering & System Safety, 139(-):120–130, 2015.
- Youming Lin, Teemu Kämäräinen, Mario Di Francesco, and Antti Ylä-Jääski. Performance evaluation of remote display access for mobile cloud computing. Computer Communications, 72(-):17–25, 2015.
- Madhusanka Liyanage, Ahmed Abro, Mika Ylianttila, and Andrei Gurtov. Opportunities and challenges of software-defined mobile networks in network security perspective. IEEE Security and Privacy Magazine, 2015.
- Hanna Mäenpää, Arto Vihavainen, Samu Varjonen, and Sasu Tarkoma. Blending problem- and project-based learning in internet of things education: Case Exact Greenhouse. Internet of Things, 2015(1):49–52, 2015.
- Weixiong Rao, Roman Vitenberg, Lei Chen, and Sasu Tarkoma. MTAF: An adaptive design for keyword-based content dissemination on DHT networks. IEEE Transactions on Parallel and Distributed Systems, 26(4):1071–1084, 4 2015.
- Antti Siirtola and Keijo Heljanko. Parametrised modal interface automata. ACM Transactions on Embedded Computing Systems, 14(4):1–15, 2015.

Network Society (NS) Programme

The mission of the Network Society research programme is to empower ubiquitous users with transparent and resourceful ICT with the following example challenges:

Maximum User Performance in Mobile Interaction: Numerous factors limit the mobile user's ability to interact efficiently with a mobile device. We are interested in exposing these factors through controlled experimentation and developing interaction techniques and methods that improve user performance.

Engaging and Embodied Interaction Across Modalities: Developing techniques and interactive systems utilising implicit and explicit interaction to foster co-experience, learning, physical and creative activity. This research is carried out by coupling in-depth user studies with design in the area of novel interfaces.

Service design, Media Experience and Media Crowdsourcing: theories and methodologies for user-centered service design, understanding of critical elements of media experience (e.g. playfulness and co-experience) through user research, laboratory experiments, and explorative designs. Media crowdsourcing: co-creativity in digital content creation, optimization of crowdsourcing tasks, creation of applications and games that utilise/ produce metadata and media.

Emotional-Social Interaction: To understand emotional and cognitive processess during ICT-mediated social interaction. This research is carried out by using neurophysiological recordings, for example.

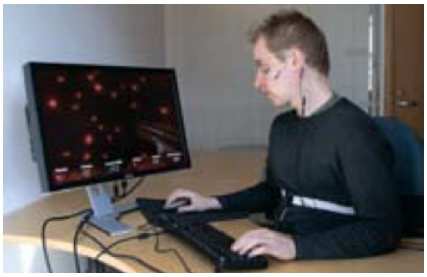
Digital Content Communities, Professor Marko Turpeinen

Our research focuses on social computing, i.e., information systems that enable and support social creativity, participatory media and distributed problem solving. However, to develop successful new technologies, and bear responsibility of design decisions, we as developers should understand and anticipate the dynamics of technology-society interaction. This requires multi disciplinary end-to-end research from technological platforms to various viewpoints to their impact on the use environment.

The goal of our research is to enable and encourage people to belong to communities of content creators, to develop service design methodology and business model development for social media, to study how people interact with each other using digital content, and to understand what new business opportunities and social structures emerge around community-generated content and technology. One of our strong focus areas is the rapidly expanding social forms of gaming and how to apply the findings from online games to other non-gaming domains. This includes virtual economies and virtual consumerism, and applying economics and business studies in virtual worlds.

Digital Content Communities is a joint research group of both HIIT and EIT Digital Helsinki node.

Key publications:



- Sampsa Hyysalo, Pia Helminen, Samuli Mäkinen, Mikael Johnson, Jouni K. Juntunen, and Stephanie Freeman. Intermediate search elements and method combination in lead-user searches. International Journal of Innovation Management, 19(1), 2015.
- Matti Nelimarkka, Vilma Lehtinen, Antti Ukkonen, Kai Kuikkaniemi, and Giulio Jacucci. Threading and conversation in co-located chats. Computers in Human Behavior, (53):324–331, 2015.
- Ehsan Amid, Aristides Gionis, and Antti Ukkonen. A kernel-learning approach to semi-supervised clustering with relative distance comparisons. In European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases (ECML/PKDD) 2015, page 234, Porto, Portugal, September 2015. Springer International Publishing.
- Airi Lampinen, Kai Huotari, and Coye Cheshire. Access to participation in the sharing economy: The case of local online exchange in a single parents' network. In Erika et al. Pearson, editor, IR15: Boundaries and Intersections. Association of Internet Researchers, United States, 2015.
- Matthijs van Leeuwen and Antti Ukkonen. Same bang, fewer bucks: Efficient discovery of the cost-influence skyline. In 2015 SIAM International Conference on Data Mining, May 2015.
- Jouni Vepsäläinen, Antonella Di Rienzo, Matti Nelimarkka, Jouni A. Ojala, Petri Savolainen, Kai Kuikkaniemi, Sasu Tarkoma, and Giulio Jacucci. Personal device as a controller for interactive surfaces. In Proceedings of the 2015 International Conference on Interactive Tabletops & Surfaces - ITS '15, pages 201–2014, 2015.

Social Interaction and Emotion (SIE), Professor Niklas Ravaja

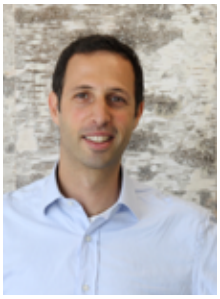
The mission of SIE is to increase our understanding of ICT-mediated social interaction. Our studies focus on: (a) emotional and cognitive processes during mediated social interaction, including mediated touch, interaction with virtual humans, and knowledge work, (b) the neuroscience of social ICT, (c) socially-mediated behavioral phenomena in SNSs, (d) the use of gamification to support the adoption of healthier lifestyles, and (e) user experience of ICT.

We use a wide methodological approach, from surveys and qualitative methods to neurophysiological recordings (e.g., EEG), to study users in the laboratory as well as in real-life contexts. By providing both fundamental and applied insight into social interaction, we help to create ICT and services that take the human social and emotional processes into account.

Key publications:

- Anssi Peräkylä, Pentti Henttonen, Liisa Voutilainen, Mikko Kahri, Tuire Stevanovic, Mikko Sams, and Niklas Ravaja. Sharing the emotional load: Recipient affiliation calms down the storyteller. Social Psychology Quarterly, 78(4):301–323, 2015.
- Deborah Serrien and Michiel Sovijärvi-Spapé. Hemispheric asymmetries and the control of motor sequences. Behavioural Brain Research, 283:30–36, 2015.
- Michiel M. Spapé, Imtiaj Ahmed, Giulio Jacucci, and Niklas Ravaja. The self in conflict: Actors and agency in the mediated sequential Simon task. Frontiers in Psychology, 6, 3 2015.
- Michiel M. Spapé, Eve E. Hoggan, Giulio Jacucci, and Niklas Ravaja. The meaning of the virtual Midas touch: An ERP study in economic decision making. Psychophysiology, 52(3):378–387, 3 2015.
- Minna Stenius, Nelli Hankonen, Ari Haukkala, and Niklas Ravaja. Understanding knowledge sharing in the work context by applying a belief elicitation study. Journal of Knowledge Management, 19(3):497–513, 2015.
- Stephan Verschoor, Marcus Paulus, Michiel Sovijärvi-Spapé, Szilvia Biro, and Bernhard Hommel. The developing cognitive substrate of sequential action control in 9-to 12-month-olds: Evidence for concurrent activation models. Cognition, 138(-):64–78, 2015.

Ubiquitous Interaction (UiX), Professor Giulio Jacucci



Ubiquitous Interaction contributes to research in human-computer interaction, in adaptive and affective interfaces, in multimodal interaction an in exploratory search and social computing. Application areas range from sustainability and environmental awareness, home computing, walk-up-and-use display, information exploration, and persuasive computing to scientific and knowledge work.

Key publications:

- Khalil Klouche, Tuukka Ruotsalo, Diogo Cabral, Salvatore Andolina, Andrea Bellucci, and Giulio Jacucci. Designing for exploratory search on touch devices. In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems, pp. 4189-4198, 2015.
- Tuukka Ruotsalo, Giulio Jacucci, Petri Myllymaki, and Samuel Kaski. Interactive intent modeling: Information discovery beyond search. Communications of the ACM, 58(1):86–92, 2015.
- Giulio Jacucci, Stephen Fairclough, and Erin T. Solovey. Physiological computing. Computer : a publication of the IEEE Computer Society, 48(10):12–16, 10 2015.
- Michiel M. Spapé, Eve E. Hoggan, Giulio Jacucci, and Niklas Ravaja. The meaning of the virtual Midas touch: An ERP study in economic decision making. Psychophysiology, 52(3):378–387, 3 2015.
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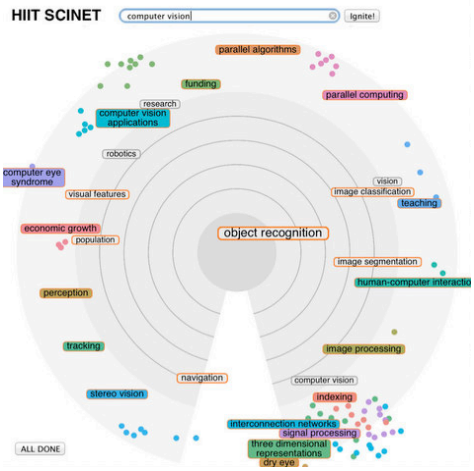
- Oswald Barral, Manuel J.A. Eugster, Tuukka Ruotsalo, Michiel M. Spapé, Ilkka Kosunen, Niklas Ravaja, Samuel Kaski, and Giulio Jacucci. Exploring peripheral physiology as a predictor of perceived relevance in information retrieval. In Proceedings of the 20th International Conference on Intelligent User Interfaces (pp. 389-399), ACM 2015.

HIIT-Wide Focus Area: Augmented Science

Augmented search, research, and knowledge work are the main themes of the multidisciplinary HIIT-wide research initiative that is a strategic research focus of HIIT. Several research groups ranging from Human-Computer Interaction to Machine Learning and Complex Systems Computation collaborate to produce cutting edge research and demonstrations that go beyond individual research papers. The project investigates how Human-Computer Interaction and Probabilistic Machine Learning can be combined to a loop that will increase, by order of magnitude, the effectiveness of search and knowledge work. We are applying our research to scientific data and work environments as well as industrial settings. The methods and tools will be able to better utilize the massive explosion of raw data, documents, distributed information and link structures between these, and sensory information recorded from the users. The methods and pilot applications are expected to revolutionize our work practices in data-driven fields such as modern biology, business intelligence, and others. In particular improving the general problem solving method of science, research, and development, in collaboration with the other fields, is the best way for our research community to contribute to solving the grand challenges of humanity.



Key publications:

- Tuukka Ruotsalo, Giulio Jacucci, Petri Myllymäki, and Samuel Kaski. Interactive intent modeling: information discovery beyond search. Commun. ACM 58, 1, 86-92. January 2015.
- Kumaripaba Ahukorala, Alan Medlar, Kalle Ilves, and Dorota Głowacka. Balancing Exploration and Exploitation: Empirical Parameterization of Exploratory Search Systems. In Proceedings of the 24th ACM International on Conference on Information and Knowledge Management (CIKM '15). ACM, New York, NY, USA, 1703-1706. October 2015.
- Salvatore Andolina, Khalil Klouche, Diogo Cabral, Tuukka Ruotsalo, and Giulio Jacucci. InspirationWall: Supporting Idea Generation Through Automatic Information Exploration. In Proceedings of the 2015 ACM SIGCHI Conference on Creativity and Cognition (C&C '15), 103-106. June 2015.
- Antti Kangasrääsiö, Dorota Głowacka, and Samuel Kaski. Improving Controllability and Predictability of Interactive Recommendation Interfaces for Exploratory Search. In Proceedings of the 20th International Conference on Intelligent User Interfaces (IUI '15), 247-251. March-April 2015.
- Salvatore Andolina, Khalil Klouche, Jaakko Peltonen, Mohammad Hoque, Tuukka Ruotsalo, Diogo Cabral, Arto Klami, Dorota Głowacka, Patrik Floréen, and Giulio Jacucci. IntentStreams: Smart Parallel Search Streams for Branching Exploratory Search. In Proceedings of the 20th International Conference on Intelligent User Interfaces (IUI '15), 300-305. March-April 2015.
- Oswald Barral, Manuel J.A. Eugster, Tuukka Ruotsalo, Michiel M. Spapé, Ilkka Kosunen, Niklas Ravaja, Samuel Kaski, and Giulio Jacucci. Exploring Peripheral Physiology as a Predictor of Perceived Relevance in Information Retrieval. In Proceedings of the 20th International Conference on Intelligent User Interfaces (IUI '15), 389-399. March-April 2015.

Administration

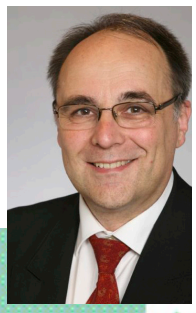
HIIT is a joint research institute of Aalto University and the University of Helsinki. The contract between the two universities was renewed in 2015, again emphasizing that the two universities will fund HIIT with equal shares and ensure the necessary basic funding. The Statutes of HIIT were renewed as well, with minor amendments.

Personnel and funding

At Aalto University, HIIT researchers currently work in the Department of Computer Science, School of Science. An administrative merge was made in the beginning of 2016 to provide HIIT's services via the Computer Science department. This does not restrict researchers from other departments in joining HIIT's activities. At University of Helsinki, our operations are at the Department of Computer Science, Department of Mathematics and Statistics, and Department of Social Sciences. The personnel of HIIT are employed by the two parent universities. Many of HIIT's personnel have double affiliations. The most common is an affiliation with other Departments of one or both of the parent universities, but there are also some who share their time between HIIT and some other organisation. Thus the total number of HIIT affiliated personnel is much higher than the number of person-years, 138.

The total funding of HIIT in 2015 was 9 MEur, of which 80 per cent was competitive. The main funding sources were Academy of Finland, Tekes, EU and the mother universities. More details will be given in the Facts and Figures document found via http://www.hiit.fi/abouthiit






Board

The highest decision-making body of HIIT is the Board. It decides on HIIT's overall research strategy and research programmes. The statutory tasks of the Board are to approve the annual budget and activity plans, and follow up and comment on the work of HIIT through regular activity updates given by the Director of HIIT. In 2015 the Board convened four times.

The HIIT Board consists of nine members who are appointed for four years at a time. Each university appoints four board members, two of which are university staff and two are not employed by the university, and personal deputies to each of them. The staff of HIIT selects one board member and his or her deputy from among their colleagues. In 2015, the Board consisted of the following members (personal deputies in parentheses):

- Chairman: Dean, Professor Risto Nieminen, Aalto (Professor Jouko Lampinen, Aalto)
- Vice chairman: Dean, Professor Jouko Väänänen, UH (Vice Dean, Professor Esko Ukkonen, UH)
- Professor Pekka Orponen, Aalto (Professor Lauri Savioja, Aalto)
- Professor Sasu Tarkoma, UH (Professor Valtteri Niemi, UH)

- Vice President Hannu Kauppinen, Nokia Oyj (Director Jyri Huopaniemi, Nokia Oyj)
- Docent Kari-Pekka Estola (Director Ville Peltola, The Federation of Finnish Technology Industries)
- Director Mervi Karikorpi, The Federation of Finnish Technology Industries (Director Petri Vasara, Pöyry Management Consulting Oy)
- CEO Harri Valpola, Curious AI (CEO Kimmo Kiviluoto, Enreach Solutions)
- Personnel representative: Docent Antti Honkela, HIIT (Dr. Antti Jylhä, HIIT

The Director of HIIT, Professor Petri Myllymäki, is responsible for preparing and submitting propositions to the Board. Board Secretary is Vice Director, Docent Ella Bingham.




Scientific Advisory Board (SAB)

The SAB consists of internationally prominent scholars who are invited by the HIIT Board. The SAB convened in 2012 and its recommendations were actively taken into account afterwards. The next SAB meeting is planned for autumn 2016. The members of the SAB are:

- Professor John Shawe-Taylor, University College London, UK; Chairman of the SAB
- Professor Elisabeth André, University of Augsburg, Germany
- Professor Richard Durbin, Wellcome Trust Sanger Institute, UK
- Professor Jodi Forlizzi, Carnegie Mellon University, USA
- Professor Seif Haridi, Swedish Institute of Computer Science, Sweden
- Professor Michael Mahoney, University of California Berkeley, USA
- Professor Kari-Jouko Räihä, University of Tampere, Finland
- Professor Wojciech Szpankowski, Purdue University, USA