



Computer Science

Man and Machine



Bar-Ilan University

→ → → Today, the most important keeper of information is the computer, and it is in the fast-moving field of computer science that Bar-Ilan researchers are making their mark.

Pictured from left to right: →

Top:

Dr. Liam Roditty

Prof. Moshe Lewenstein

Prof. Nathan Netanyahu

Dr. David Sarne

Middle:

Prof. Amir Herzberg

Prof. Yehuda Lindell

Prof. Benny Pinkas

Bottom:

Prof. Shmuel Tomi Klein

Prof. Yonatan Aumann

Prof. Ely Porat

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Illustration of Stonehenge

Ever since the ancient builders of Stonehenge erected a circle of stones for tracking celestial events, humankind has relied on technology to keep track of their most important information. Today, the most important keeper of information is the computer, and it is in the fast-moving field of computer science that Bar-Ilan researchers are making their mark.

BIU helps set the global CS research agenda. Its faculty members help plan all the most important computer science conferences, edit leading journals, and have created entirely new fields of inquiry. This dynamism fuels faculty recruitment from top institutions including MIT, Harvard, NASA and Bell Labs. In the latest Academic Ranking of World Universities (ARWU), the BIU CS department appears among the 100 best Computer Science departments in the world.

A growing reputation for excellence in both applied and theoretical research has made Bar-Ilan's Department of Computer Science a team to watch.

Ahead of the Game – the ROBOCUP Challenge

In 2009, Prof. Gal Kaminka led the first-ever Israeli “delegation” to RoboCup, a robotics competition that uses soccer as a model for integrating computer vision, motion planning, multi-agent collaboration and strategy. Beyond the playing field, autonomous robot teams are useful in household tasks, search and rescue missions, and defense. Kaminka has devised robot-team methods for patrolling borders – significantly reducing infiltrators’ ability to breach defenses – and for searching buildings under the supervision of a human operator. Kaminka is also building cognitive models of humans – computer programs that can behave like humans, and understand human actions and intent.

➔ **BIU research helps
computers infer meaning from
human language.**

Multi-Agent Artificial Intelligence

Another BIU researcher advancing the cause of computer “teamwork” is Prof. Sarit Kraus. Winner of the 2010 EMET Prize, Kraus developed algorithms that allow computers to conduct negotiations with people and with each other. Kraus designed an agent that assisted in the collection of data on cultural differences between the United States and Lebanon. With her American collaborators, Kraus also created an award-winning security system used by security personnel at Los Angeles International Airport.

Dr. David Sarne, a BIU alumnus, also focuses on multi-agent artificial intelligence and negotiation. Sarne devises models that figure in the economic impact of choosing the optimal agent for a particular task, and allows computerized agents to minimize the expected cost of an overall search. He has also demonstrated how multi-agent decision making based on self-interested comparison shopping agents can in some cases result in both lower expense to buyers and higher net revenues to sellers.



Software and Hardware Verification

The multi-billion dollar software industry depends on software engineers – the individuals who write computer programs. But how can we be sure that a computer program does what it is supposed to do? Prof. Doron Peled is one of the world's leading experts on "Formal Verification" – the science of creating programs that automatically verify the correctness of software. While creating such programs is difficult – indeed, sometimes impossible! – Prof. Peled's foundational and highly cited books and papers define exactly what verification can and cannot be achieved.

Natural Language Processing

Can computers take human language and interpret it within an applied computation framework? This is the challenge of Natural Language Processing (NLP), a field that is particularly strong at Bar-Ilan. In over a decade focusing on empirical and learning methods for language processing by computers with a particular emphasis on unsupervised semantic learning, Prof. Ido Dagan introduced the concept of "textual entailment"

– a general framework for inferring target meanings phrased in natural language from given texts. The importance of Dagan's work has been recognized with numerous awards, including the prestigious Wolf Foundation Krill Prize and an IBM Faculty Award.

Another NLP expert is Prof. Moshe Koppel. In a recent achievement, Koppel developed a computer program that can determine whether a book was written by a man or a woman. Strikingly, the distinctions between male and female writers are much the same as those that, even more clearly, differentiate non-fiction and fiction. Using a similar process, Koppel's program can tell these two genres apart with 98% accuracy.

The Security Connection

Privacy is at a premium on the Internet. In EU-funded cryptography research, Prof. Yehuda Lindell hopes to create a privacy infrastructure that will prevent outsiders from creating "profiles" of individuals' online activities. He is also developing a model for secure sharing of information among institutions, by blocking unnecessary information flow, while providing secure access to the data that's really needed.

Prof. Amir Herzberg – a leading expert on applied cryptography – has analyzed the way in which standard security measures often fail to protect Internet users from fraudulent email messages, as well as “spoofed” webforms designed to steal passwords. To address such dangers, Herzberg created *TrustBar*, a tool that identifies sites, verifies their legitimacy, and warns users about potential problems. Herzberg also analyzes the vulnerability of the Internet’s Domain Name System (DNS) – a hierarchical naming system for network-based resources that is highly vulnerable to cyber-attack.

➔ **BIU is home to one of the world’s most formidable computer theory teams, excelling in pattern matching – an important aspect of data base technology – as well as algorithms, complexity theory and verification.**

Also in cryptography, Prof. Benny Pinkas focuses on secure multi-party computation – a theoretical conundrum best described by the “millionaires’ problem,” in which two millionaires want to find out who is richer, without revealing their actual worth. Pinkas aims to create software-based tools that can build this functionality into computational technologies. In another project – cited as IEEE’s “Best Paper on Security and Privacy” for 2010 – Pinkas demonstrated a real-time face identification system that reduces the privacy impact of camera-based surveillance.



Computer Theory

Pattern matching expert Prof. Amihud Amir, a Bar-Ilan alumnus, has served on the program committee of dozens of major conferences and is currently on the editorial board of “Information and Computation”, an international journal of Computer Science. Amir is a former director of the Bar-Ilan Responsa Project – an initiative that in 2007 was awarded the Israel Prize for linking one of the largest-ever electronic databases of Torah literature to advanced retrieval software. Amir recently used his own theoretical advances in the areas of multidimensional pattern matching, compressed matching, and asynchronous matching to create novel algorithms for use in Computational Biology.

Another theoretician is BIU alumnus Prof. Moshe Lewenstein. A noted expert on the analysis of algorithms used in pattern matching and data structure design, Lewenstein is a prolific author who lectures worldwide. He is currently creating data structures for indexing – an area of inquiry that, among other issues, seeks to build “error tolerance” into rapid search engines. He is also examining the use of “approximation algorithms” on difficult textual search problems.

The primary field of Prof. Ely Porat is pattern matching, but his interdisciplinary research encompasses data structures, coding theory, group testing, streaming algorithms, compress sensing and game theory. A PhD at the age of 21 who went on to become Israel’s youngest professor, Porat holds visiting positions at the

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University of Michigan and Tel Aviv University, and has collaborated with many companies including Google, Yahoo, Microsoft, CheckPoint and IBM.

In today's data-rich world, information is stored in both words and pictures. Image processing expert Prof. Nathan S. Netanyahu draws on techniques of algorithm design and analysis, computational geometry, remote sensing, and statistical methods for his research, which has application in both the defense and aerospace industries. Netanyahu – who has worked for the Israeli Ministry of Defense and NASA – is co-editor of *Image Registration for Remote Sensing*, to be published shortly by Cambridge University Press.

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Prof. Shmuel Tomi Klein is an expert in lossless Data Compression. He is the author of the compression tool incorporated into MS-DOS and recently co-invented a deduplication method for IBM – a technology that allows clients to store significantly increased backup data on disk and has the added effect of reducing the network bandwidth. A former Chief Scientist of the BIU Responsa Project who also conducts research on Information Retrieval, Klein has served as a consultant to the Trésor de la Langue Française project at the University of Chicago.

Prof. Yonatan Aumann's theory-based work encompasses fields including algorithms, computational biology, algorithmic game theory, and Artificial Intelligence. Together with multi-agent AI experts Sarit Kraus and David Sarne, Aumann develops the theory governing the interactions between agents, focusing on understanding the sources and mechanisms for adversarial and cooperative behavior

of agents, and on designing strategies for promoting effective inter-agent cooperation. In a study on adversarial behavior conducted together with Prof. Yehuda Lindell, Aumann is also examining efficient methods for secure computations among multiple agents.

Dr. Tali Kaufman, an Alon Scholar who recently joined the Department after completing post-doctoral research at both MIT and Princeton's Institute of Advanced Studies, is an expert on complexity theory – a field that helps computer scientists identify the limits of what can be achieved with a defined set of resources. Kaufman studies mathematical structures that would make it possible read a small amount of information from a damaged storage device — such as a computer disc — and by so doing, determine the number of errors in the disc as a whole. The goal of Kaufman's research is to create mathematical strategies for robust preservation of computerized data.

Dr. Liam Roditty studies the theoretical underpinnings supporting automated computation of the shortest path between two locations – a functionality familiar to anyone who has ever looked up driving directions online. Using graph algorithms, dynamic algorithms and game theory to explore several variants that influence identification of the optimal path, Roditty's work is paving the road to improved map generation in the future.

Moving Computation Forward

Computer Science research at Bar-Ilan is helping individuals and organizations harness information and use it for the advancement of science, for the improvement of industrial processes, and for the betterment of our day-to-day lives. By standing at the forefront of this rapidly expanding field, BIU researchers are strengthening the knowledge-based economy of the State of Israel, and making an important contribution to the world as a whole.



For more about the research of BIU faculty listed in this brochure go to: www.biu.ac.il and click [Research](#).



BIU's Uziel Spiegel
Mathematics and
Computer Center

Bar-Ilan University Science and Technology

Bar-Ilan University stands at the forefront of cutting-edge research. Bar-Ilan researchers are making breakthroughs that improve life around the globe in areas such as drug-development, nanotechnology, medical research, bio-engineering, microscopy, optics, communications, energy, security, and more. As part of a national program to combat Israel's brain drain, BIU has taken the lead by committing to absorb dozens of returning experimental scientists within its world-class research infrastructure, and has added state-of-the-art physical facilities in engineering, brain sciences and nanotechnology to house these innovative initiatives. The Science and Technology Series highlights some of the University's most exciting research endeavors.



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