Science & Technology Series

Communications and Security Research

Connections You Can Count On

Tradition of Excellence

Bar-Ilan University

By helping to strategize new routes for the production and coordination of information across long distances, Bar-Ilan researchers are making an important contribution to scientific advancement.

Pictured from left to right:
Prof. Ido Dagan
Prof. Sharon Gannot
Prof. Amir Leshem
Prof. Zeev Zalevsky

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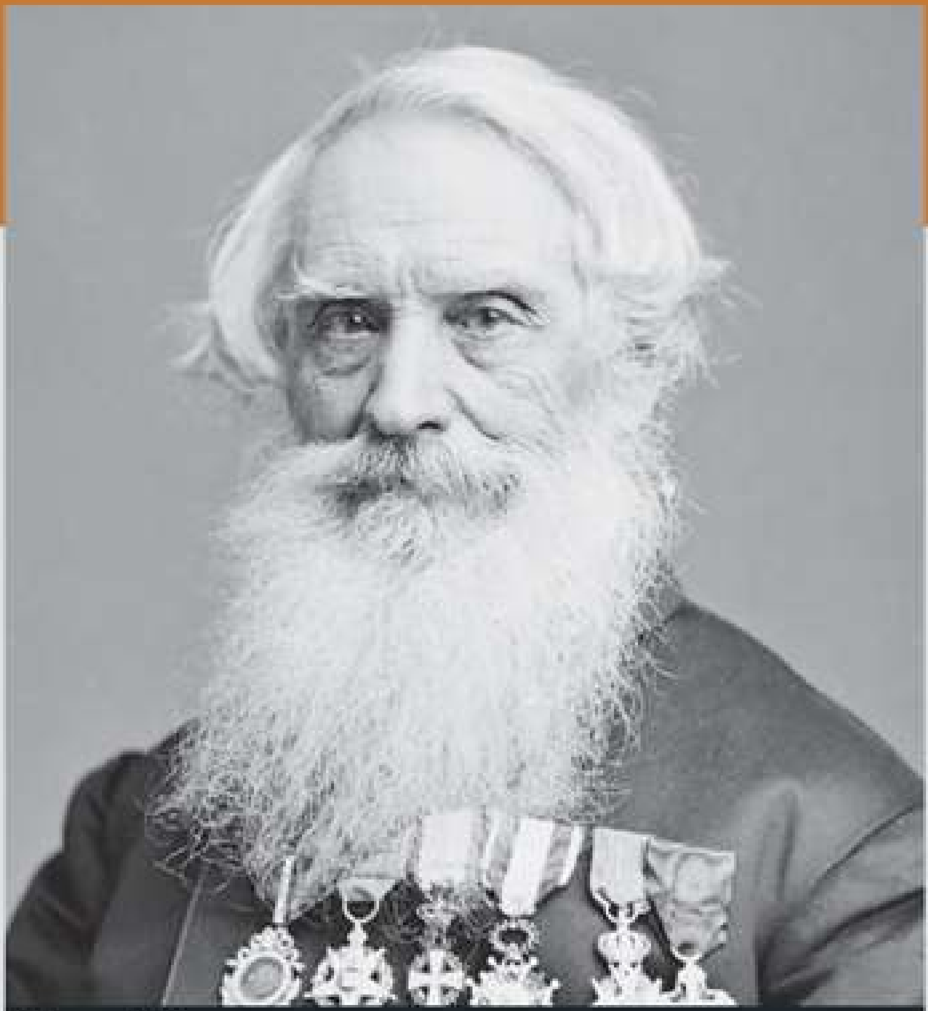

Samuel Morse

When telegraph pioneer Samuel Morse transmitted his first message along just 40 miles of wire in 1844, he chose the Biblical verse: "What hath God wrought?" Today, scientific advances in communications technology allow messages to circle the globe in the blink of an eye. Even God's heavens – now studded with message-bouncing communications satellites – don't seem so remote anymore.

At Bar-Ilan University, a core group of specialists are advancing the discoveries needed to share and protect knowledge transmitted over networks. Some are developing new technologies for signal identification and transmission. Others are designing the materials destined for use in tomorrow's communications devices. Still others are advancing theoretical models for optimizing signal transfer, or creating new solutions for information security. Finally, BIU scientists are also re-defining what it means to communicate, by creating new protocols for the interface between man and machine, and between machines themselves.

From smoke and flag signals, to the invention of lead pencils, to the advent of the Internet, communication technologies have profoundly influenced the evolution of societies, and helped them advance their personal, military and industrial agendas. By helping to strategize new routes for the production and coordination of information across long distances, Bar-Ilan researchers are making an important contribution to Israel, and the world as a whole.

Starting from Signals

As anyone who has tried to conduct a quiet conversation at a noisy party can attest, it can be difficult to separate specific sounds from environmental interference. Extracting the "pure" signal is the specialty of Prof. Sharon Gannot, head of the Speech and Signal Processing Laboratory at BIU's School of Engineering. In work relevant to medical applications for the hearing impaired, intelligence gathering, and the improvement of teleconference and cellphone technologies, Gannot uses multiple microphone arrays and advanced computer algorithms to acquire, analyze and enhance speech signals. By studying spatial components as well as waveform characteristics, Gannot is able to separate the digital "wheat from the chaff" and make sure the message gets through – loud and clear. In the summer of 2010, Prof. Gannot co-chaired the International Workshop on Acoustic Echo and Noise Control (IWAENC), one of the most prestigious conferences in the field, which was held in Israel for the first time.

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Can computers be made to understand human speech? This is one of the challenges behind the Natural Language Processing (NLP) research of Prof. Ido Dagan. Focusing on empirical and learning methods for language processing by computers with a particular emphasis on unsupervised semantic learning, Dagan pioneered the concept of "textual entailment" – a general framework for allowing computers to infer meaning from texts. Dagan's work – which extends to the realm of speech identification as well as the written word – demonstrates how common human conversational "domains" such as economics, politics

or law can provide an unsupervised computer system with the coherent lexical framework needed to correctly interpret speech-based signals. The importance of Dagan's work has been recognized with numerous awards, including the Krill Prize and an IBM Faculty Award.

Transmission Begins

Information is power, but will existing networks have the power to handle increasing demand for wireless communication? According to Profs. Amir Leshem and Ephraim Zehavi, the future of wireless technologies such as cellphones and high-speed Internet depends on limiting interference through the encouragement of efficient sharing of unlicensed bandwidth resources. In order to limit the mutual interference created by the massive use of technology over a relatively small number of channels, Leshem and Zehavi have proposed a "game theory" based solution in which competing channels optimize their use of resources by sharing some basic information. This model – based on the "Nash Bargaining Solution" – yields a significant gain in efficiency over a purely competitive framework.

Also tackling the problem of interference is Dr. Itzik Bergel, who develops methods for interference mitigation in wireline and wireless communication systems. His research focuses on the use of limited cooperation between terminals to increase the data rates of all users in the network. Bergel's methods bridge the gap between the ideal performance predicted by theory – which, because of computational complexity, cannot be achieved in the real world – and modern, state-of-the-art communication systems. His techniques can be applied to various platforms, including DSL wireline systems and wireless ad-hoc networks (such as wireless LAN).

Speaking of complexity, when planning communications networks, it is important to plan for efficient – and realistic – use of resources. The work of Dr. Shraga Bross focuses on the analysis of the ultimate capabilities of various communication models. Bross' research suggests strategies for efficient operation of underlying systems, in order to achieve the best possible performance.

Prof. Zeev Zalevsky is an expert on photonics – a field of inquiry that relates to the controlled manipulation of light-matter interactions on the nano scale. Zalevsky recently patented a "thinner than hair" optical fiber that may be used as the basis for interference-resistant communication cables that are screened from the environment. The invention may also be applied to tasks in biomedicine, electronics and environmental sensing. In another project, Zalevsky has constructed nanophotonic "modulators" fabricated on silicon chips that use either electrical voltage or the application of a magnetic force to control the intensity of light moving through optical communications systems. He has also developed a photonics-based tool for analyzing and manipulating radio frequency signals.

BIU researchers are fabricating materials for use in communications components that will integrate traditional electronics with the data-encoding power of light.

The demand for faster communications devices means that more and more transistors are being squeezed onto computer chips. But with speed comes heat – and lots of it. Dr. Avi Zadok is "offloading" some of this processing pressure, through hybrid components that integrate traditional silicon-based electronics with the data-encoding power of light. Working together with Prof. Chaim Sukenik, Zadok has fabricated layered "sandwiches" of silicon and a light-producing material, resulting in a device that translates electric charge into an optical signal. The goal of this "silicon photonics" research is to develop optical communications components for use in the multi-processor computer systems of the future.

Keeping It Safe

When sensitive information – like a credit card number – is sent over the Internet, it is scrambled to protect the sender's privacy, then unscrambled at the receiving end. Profs. Michael Rosenbluh and Ido Kanter have clarified the way in which chaotically-generated laser light can also be used as an encryption tool. The scientists demonstrated how, when two lasers emitting random pulses are trained one upon the other, they begin to synchronize, eventually "firing" in an exactly coordinated pattern. This phenomenon could be used to send uncrackable, coded messages over long distances.

In theory, quantum cryptography – the use of quantum systems to encrypt information securely – is perfectly secure. It exploits the fact that it is impossible to make measurements of a quantum system without disturbing it in some way. In practice, however, no quantum cryptographic system is perfect, and unfortunately, the most prevalent present-day alternatives are inefficient and susceptible to quantum computer-based attack. The research of Dr. Boaz Tsaban deals with a fascinating new branch of cryptography that seeks to find public-key systems that will make encoded information immune to the potential threat of future quantum computers. Tsaban's mathematical methods – based on combinatorics and group theory – may lead to new and powerful techniques for protecting proprietary information transmitted through communications networks. Tsaban is a recipient of the 2009 Krill Prize for Excellence in Scientific Research.

Research

Internet Security

The Internet has made communication easier than ever, but there's a cost. According to Prof. Yehuda Lindell, whenever we're online we reveal an enormous amount of information we never meant to share. In EU-funded cryptography research, Lindell is designing 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.

BIU research is laying the groundwork for the communication, coordination and cooperation paradigms of the future.

"Denial of Service" (DoS) is a pernicious form of cyber-attack in which a user or organization is deprived of an Internet resource they would normally expect to have. Prof. Amir Herzberg – a leading expert on applied cryptography – develops strategies for protecting the Internet from DoS, as well as spam, eavesdropping and "phishing" – the practice of using fraudulent email forms in an attempt to steal passwords and other proprietary information. Currently, Herzberg and his team are working on next-generation protocols for secure financial trading that will empower individual investors to control their assets directly rather than depending on centralized – and expensive – professional services. This line of research may drastically change the way people do business, similarly to the way in which the Internet itself "democratized" the communication market.

Prof. Ely Porat is an expert in pattern matching and algorithm design who collaborated with many companies – including Google, Yahoo, Microsoft, CheckPoint and IBM – on security management systems for computers and networks. His recent work on "intrusion detection" involves creating algorithms for identifying possible security breaches originating both outside and inside an organization, while assessing the vulnerability of the overall system.

Beyond Words

The data we communicate allows us to understand each other, and coordinate our actions. Prof. Gal Kaminka is expanding the definition of communication, by developing advanced models for cooperation within teams of autonomous robots. Combining computer vision, motion planning, multi-agent collaboration and strategy, 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. In another project, Kaminka and his students have developed the world's fastest algorithm for detecting anomalous – and suspicious – sequences of action, a technology that can be applied to automatic video surveillance. Kaminka is also building cognitive models of humans – computer programs that can understand human actions and intent.

Have You Heard?

Scientific advances related to communications are central to Israel's prominent position in the global high-tech industry. But the innovative discoveries coming from Bar-Ilan's research laboratories are creating more than just a business buzz. BIU research is laying the groundwork for the communication, coordination and cooperation paradigms of the future.

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

Security

BIU's School
of Engineering

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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Bar-Ilan University
Ramat Gan 52900, Israel
www.biu.ac.il