ABC Robotics Initiative

Agricultural
Biological
Cognitive

אוניברסיטת בן-גוריון בנגב
Ben-Gurion University of the Negev

abc
agricultural biological & cognitive robotics

Doing it for Themselves

Ben-Gurion University of the Negev is at the cutting edge of robotics research with a proven competence in a wide range of overlapping fields. Our research teams have won significant international recognition for their work and are at the forefront of developing robots that interact with their surroundings and respond accordingly. As the mechanics of robots becomes increasingly more sophisticated, so has the expectation that they will be able to function independently in more complex scenarios free of human supervision, as well as those dependent on intelligent human-robot interactions.

This ability to absorb and process sensory information will enable robots to continuously adapt themselves to their new environment and functions. To enter real-world settings, robots must be endowed with human-like cognitive capabilities that allow them to cope with dynamic, non-deterministic and unstructured human-populated environments.

In order to do this, they must be equipped with advanced perception, dexterity and manipulation, as well as the ability to adjust to changing conditions and to master new tasks efficiently. They also need to have the physical and behavioral characteristics that will make their social interaction agreeable to human beings.

"Our researchers are looking at robotics holistically – how to move beyond sensory perception and agile movement, into a whole new cognitive realm."

Prof. Rivka Carmi
University President

Why ABC?

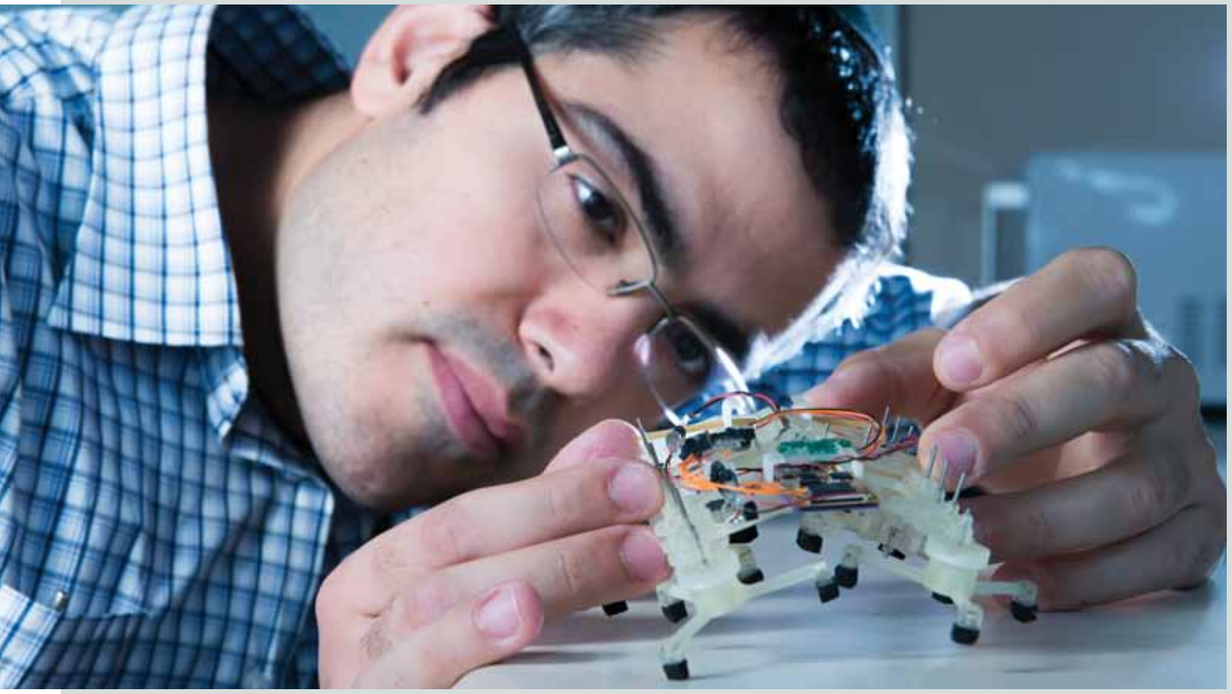
Inspired by biological models and human behavior, the newly created ABC Robotics Initiative brings together researchers who focus on developing robots endowed with "intelligent" behavior. With the support of the Helmsley Charitable Trust, BGU has identified a significant number of researchers who have the potential to contribute in paradigm-breaking ways to traditional robotics research.

The ABC Initiative seeks to bring researchers together in both familiar and unfamiliar ways, challenging them to move beyond their respective "comfort zones" in order to probe the yet unexplored. This setting offers an open, productive research environment that fosters sustainable and intensive discussions necessary for reaping meaningful insights from the different disciplines.

Moreover, this transdisciplinary approach provides ample opportunity for all those involved to challenge basic assumptions within their respective fields. A framework of encounters and engagements has been established, inspiring broader perspectives among junior and senior scientists alike.

By mapping the potential research partners in diverse fields and formulating a number of distinct projects, the Initiative hopes to facilitate the creation of innovative designs for a new generation of smart devices. This multidisciplinary, application-oriented research is accelerating the development of new robotic systems in the areas of medical, service, industrial and agricultural robotics.

The ABC Initiative is committed to furthering teaching, research, mentorship, collaboration and dissemination of information. BGU has recruited essential new faculty members and research students to enhance its capabilities, establish international collaborations with leading research groups and obtain research funds via competitive peer-reviewed grants.



A Unique Approach

The Agricultural, Biological and Cognitive robots developed in the framework of the ABC Robotics Initiative are inspired by biological models and human behavior. The robots will be able to continuously adapt themselves to their new environment and tasks, perform under unforeseen and changing working conditions and have capacities well beyond those of current autonomous robotic systems.

Agricultural Robots – The development of "intelligent" platforms for the agro-management of high-value crops and innovative human-robot collaborative models and systems, such as targeted spraying and selected harvesting of crops.

Biological Robots – Revealing the secrets of perception, cognition and action in biological systems for application in robotic systems, particularly human and animal motor-control systems, including robotic surgery, rehabilitation and human-like movements.

Cognitive Robots – Endowing robots with higher-level cognitive capabilities that allow for intelligent perception, reasoning, decision making and collaborative functioning and learning, derived from computational neuroscience, psychological, physiological and phenomenological approaches.

Our unique approach is founded on cooperations between researchers from different disciplines and seeks to create adaptable robots inspired by biological models and human behavior.

Accelerating Development

The ABC Robotics Initiative is designed to consolidate and leverage existing talents and expertise at BGU. By investing in the human factor – developing the capacity and capabilities of the researchers – the Initiative has created an ecosystem that encourages innovation and collaboration.

The core components and proposed strategic initiatives support both the academic-theoretical and the practical aspects that are part and parcel of the endeavor.

A number of specific programs were instituted with the aim of advancing the greater vision:

Focused Research Development Projects have been designed to ensure the implementation of cooperative, multidisciplinary research. The projects selected are founded on broad cooperation between faculty and students across multiple disciplines in pursuit of real-world, practical goals, while ensuring leveraging via other sources of funding.

The Helmsley Distinguished Fellows Program was established to provide special fellowships to outstanding graduate and postdoctoral researchers, as well as to bring distinguished international scholars to BGU for extended stays, during which they participate in collaborations and offer courses in their areas of expertise.

ABC Robotics Monthly Seminar brings lecturers and researchers together for a state-of-the-art lecture, thus enriching the learning environment.

ABC Robotics Annual International Conference contributes to the University's international reputation and brings recognition in the field.

The Research Projects

A-Agricultural Robotics

Human-Robot Collaborative Sprayer

We aim to create an efficient agricultural spraying robot by developing a human-robot cooperative system. The collaboration between a human being and a robot can yield a simplified, flexible and robust system that will use the advantages of both to cope with dynamic and complex conditions in the unstructured and highly variable agricultural environment, thereby improving performance. A full-scale site-specific vineyard robotic sprayer has been developed, including the mechanical design, intelligent sensing and control. The system includes several levels of human-robot cooperation; the level of cooperation and the mode of operation are determined for particular task objectives through experiments that measure performance and human workload.

Quadcopter Drone

The project aims to develop a drone for the pollination of greenhouse tomatoes, which is currently done either manually or by Bombus bees (bumblebees), by means of "buzz pollination," whereby the wind produced by the hovering bee's wings shakes the flower sufficiently to induce pollination. We seek to create a quadcopter drone that imitates the behavior of the Bombus bee as it hovers over the flowers and aims its wind at them. We aim to design an efficiently powered drone, which can produce sufficient wind, and to develop basic capabilities, such as navigation within the rows, identification of flowers through vision or other sensors, and the ability to hover over a specific flower. The drone should also be able to recharge automatically.

Guy Shani, Department of Information Systems Engineering; Gera Weiss, Department of Computer Science; Shai Arogeti, Department of Mechanical Engineering

http://www.crops-robots.eu
http://www.sweeper-robot.eu

Other Agricultural Robotics R&D

Among other projects, BGU researchers are partaking in the development of robots with an emphasis on intelligent sensing and grasping. This includes advanced image processing algorithms for detection of sweet peppers, apples and grapes, adaptive thresholding and sensor fusion algorithms for robust fruit detection in highly variable illuminated environments, sensor fusion for disease and ripeness detection, grasp and path planning algorithms and a methodology for gripper design.

Yael Edan, Department of Industrial Engineering & Management, Incumbent of the Rabbi W. Gunther Plaut Chair in Manufacturing Engineering; Ohad Ben-Shahar, Department of Computer Science; Sigal Berman, Department of Industrial Engineering & Management; Amir Shapiro, Department of Mechanical Engineering

The innovative approach of using mobile active joints will pave the way for a novel family of minimally actuated serial robots, contributing to the areas of medical, agricultural, industrial, and search and rescue robotics.

B-Biological Robots

Robotic Two-Stage Endoscope with Haptic Feedback for the Small Intestine

The objective of this research is to develop a highly maneuverable serial robot for light-weight applications, capable of penetrating confined spaces and moving around obstacles to access its targeted areas. The advantage of this robot is that it needs only a few active joints for tasks in confined spaces, whereas a conventional serial robot requires dozens of actuated joints, rendering it inefficient.

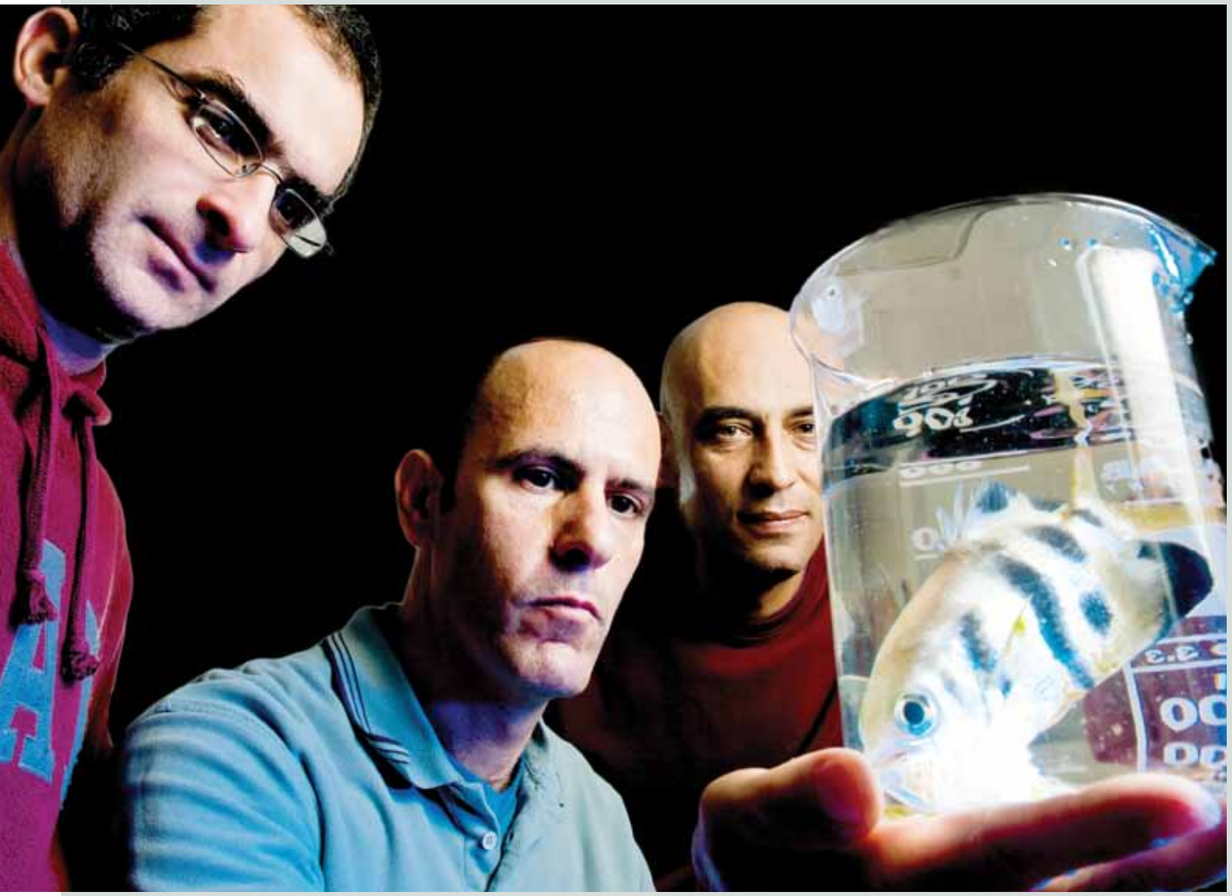
The innovative approach of using mobile active joints will pave the way for developing a novel family of minimally actuated serial robots, capable of navigating complex bifurcations and crawling on highly flexible surfaces. The technological contributions of this endeavor will be evident in several domains, specifically in the areas of medical, agricultural, industrial, and search and rescue robotics.

David Zarrouk, Department of Mechanical Engineering; Nimrod Mimon, Soroka University Medical Center; Ilana Nisky, Department of Biomedical Engineering

KEEP WALKING: Robot-Assisted Locomotor Therapy

Scientific interest in understanding the neuronal and computational basis of Locomotor Adaptation (LA) is growing. Enhanced understanding of LA is important for the treatment of several medical conditions, such as neurodegenerative diseases, stroke, cerebral palsy and deficits in the elderly that result in gait disorders. This project studies the behavioral and computational modularity of Locomotor Adaptation, investigates the neuronal underpinnings of this modularity using both functional and structural imaging approaches, examines Locomotor Adaptation deficits in older adults as well as in groups of patients suffering from gait disorders, and seeks to develop assessment and prevention programs to preserve the ability to walk and to recover unexpected loss of balance during walking in patients and elderly people.

Itshak Melzer, Department of Physical Therapy; Simona Bar-Haim, Department of Physical Therapy; Opher Donchin, Department of Biomedical Engineering; Shelly Levy-Tzedek, Department of Physical Therapy; Raziel Riemer, Department of Industrial Engineering & Management; Amir Shapiro, Department of Mechanical Engineering; Lior Shmuelof, Department of Brain and Cognitive Sciences



Towards an Archerfish Ro-Bio-Bot

The study of the archerfish's motor skills, as manifested by its water shooting during hunting, contributes to the biologically inspired implementation of an archerfish robot and to the development of an archerfish biobot controlled by external stimulation delivered to the brain by software and human operators. The archerfish biobot will be used for monitoring hazardous aquatic environments, such as off-shore oil drills. In addition, it will enable a basic understanding of the functioning of the fish's brain.

Ronen Segev, Department of Life Sciences; Ohad Ben-Shahar, Department of Computer Science; Opher Donchin, Department of Biomedical Engineering; Avishai Henik, Department of Psychology, Distinguished Professor; David Zarrouk, Department of Mechanical Engineering

C-Cognitive Robots

Tactile Perception

Using brain signals to monitor the environment and control robotic devices will no longer be a science fiction fantasy.

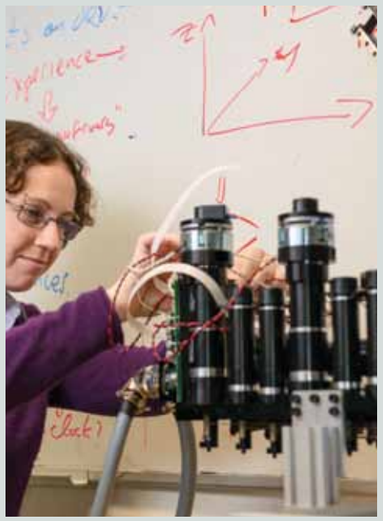
Extracting signals directly from the brain to monitor the environment and control robotic devices has been a science fiction fantasy that finally seems destined to become reality. Neurons in the brain are constantly computing the signals required to perceive the world and control biological limbs. Our inferences about brain mechanisms underlying these tasks rely on whether it is possible for the brain to "reconstruct" sensory stimuli and motor commands from the information contained in the concerted activation of ensembles of neurons. The prevailing view sees these two systems as separate. Nevertheless, sensory systems are of limited value to the organism without the participation of a motor system that moves the receptor organs into the most effective position for probing the environment.

The Brain-Computer Interface project explores aspects of such sensory-motor loops in the brain and in brain-computer interface systems. It aims to develop new cooperative brain and machine-learning paradigms in a closed-loop EEG-based setting through the application of machine-learning approaches and training protocols that have not yet been examined. The first phase of the project will focus on decoding brain activation in an open-loop paradigm using advanced machine-learning algorithms applied to EEG data. The second phase will focus on studying the interaction between machine-learning algorithms and the learning of the human subject during a closed-loop brain-computer interface task.

Rony Azouz, Department of Physiology and Cell Biology; Ohad Ben-Shahar, Department of Computer Science; David Golomb, Department of Physiology and Cell Biology; Maoz Shamir, Department of Physiology and Cell Biology; Oren Shriki, Department of Brain and Cognitive Sciences; Lior Shmuelof, Department of Brain and Cognitive Sciences

The study of the interactions between perception, action and cognition is of particular interest in teleoperated robot-assisted surgery and in industrial operations conducted in hazardous environments.

Unifying Framework for Perception, Cognition and Control in Remote Robotic Manipulation



Remote robotic manipulation requires the integration of perception, cognition and action within and between the human and robot agents. The study of the interactions between perception, action and cognition is of particular interest in teleoperated robot-assisted surgery (RAS) and in industrial operations conducted in hazardous environments.

In RAS the surgeon telemanipulates robotic instruments that are inserted into the patient's body via small incisions. While this method offers the surgeon and the patient many advantages, the effectiveness of current RAS systems is limited by the lack of force feedback. Industrial operations conducted in hazardous environments require handling products through safety cells and enclosures using varying levels of automation. One of the limiting factors in such applications is the line between stability and transparency in classical approaches to teleoperation. This boundary may be pushed by incorporating an understanding of the "perception" and "action" modalities of the operator into the control. The exploration of the effects of time delays, noise and unstable conditions is crucial to the understanding of human perception capabilities and the optimization of control strategies. We undertake these challenges from both theoretical and practical perspectives.

Sigal Berman, Department of Industrial Engineering & Management; Tzvi Ganel, Department of Psychology; Ilana Nisky, Department of Biomedical Engineering; Opher Donchin, Department of Biomedical Engineering

Autonomous Service Robot

The goal is to build mobile service robots for home and office environments that can autonomously plan and perform useful tasks. Our planning algorithms will allow the robots to combine basic capabilities in order to perform advantageous tasks without relying on pre-written scripts. The robots will receive oral commands and use speech to obtain information that can help them perform their task.

Ronen Brafman, Department of Computer Science; Ohad Ben-Shahar, Department of Computer Science; Michael Elhadad, Department of Computer Science; Guy Shani, Department of Information Systems Engineering; Amir Shapiro, Department of Mechanical Engineering

The coordination of human beings and robots in real-life settings requires the development of novel interaction tools aimed at facilitating the robot's context-sensitive and intent-based actions.

Human-Robot Interaction

A multidisciplinary team of researchers has come together to develop novel interaction tools aimed at facilitating the robot's context-sensitive and intent-based actions, based on the generation of a shared augmented mental model for both the human being and the robot. This effort is geared toward the collaboration and coordination of humans and robots in real-life settings, using Brain-Computer and additional interfaces. Interface design will include user studies in dynamic and unstructured environments.

We aim to develop the robot's visual-auditory perception, which will include a visual-acoustic stimuli generation system, based on headphones with a head-position tracker and a visual display that facilitate visual-auditory perception studies; an improved understanding of human visual-auditory perception of dynamic sources in natural scenes; and a visual-auditory computational framework for robots that facilitates scene analysis of natural environments with fixed and moving visuo-acoustic sources.

We also seek to develop and implement advanced interaction modalities, including a non-invasive robot camera-head control for teleoperations; gesture-based intuitive and robust human-robot interaction; gesture-based control of a person-following robot using depth information; and sensorless collision detection and control by physical interaction.

Tal Oron-Gilad, Department of Industrial Engineering & Management; Jihad El-Sana, Department of Computer Science; Rony Azouz, Department of Physiology and Cell Biology; Ohad Ben-Shahar, Department of Computer Science; Yael Edan, Department of Industrial Engineering & Management; Avishai Henik, Department of Psychology; Boaz Rafaely, Department of Electrical and Computer Engineering; Idit Shalev, Department of Education; Oren Shriki, Department of Brain and Cognitive Sciences; Iris Tabak, Department of Education

SEVENTH FRAMEWORK PROGRAMME

http://robot-ears.eu

Powered by People

The ABC Robotics Initiative builds upon BGU's significant competence in the field.

THE LEONA M. AND HARRY B. HELMSLEY CHARITABLE TRUST

About the Helmsley Charitable Trust

The Leona M. and Harry B. Helmsley Charitable Trust aspires to improve lives by supporting effective nonprofits in health, place-based initiatives, and education and human services. Since 2008, when the Trust began its active grantmaking, it has committed more than $1 billion to a wide range of charitable organizations. The Trust's grantmaking program in Israel supports leading institutions and initiatives that seek to strengthen the nation's leadership in scientific, technological and medical research, its health care preparedness, and its standing in the world.

Produced by the Department of Publications and Media Relations
Design: Studio Rave-Peleg
Photographs by Dani Machlis
March 2015

"The Helmsley Charitable Trust is proud to support the highly innovative robotics project at Ben-Gurion University, which will help to make the world a better and safer place."

Sandor Frankel, Trustee

ABC Robotics Initiative, established through the generous support of the Helmsley Charitable Trust

www.bgu.ac.il/abc-robotics

abc-robotics@bgu.ac.il