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Israel Institute
of Technology

ARTIFICIAL INTELLIGENCE AT THE TECHNION:

Harnessing the Power of AI to Tackle the World's Most Pressing Challenges

Ranked among the world's top universities in artificial intelligence (AI), the Technion - Israel Institute of Technology has conducted outstanding research in this field, much of which has developed into trailblazing commercial products.

The Technion collaborates with manufacturers, the high-tech industry, government agencies, R&D centers, healthcare providers and academic institutions, and boasts many researchers in the field who have gone on to found companies across the AI spectrum.

AI AT A GLANCE

Artificial intelligence is the ability of computers or computer-guided systems to perform tasks that are normally associated with intelligent beings. AI systems actively "perceive" the environment, and "learn" from experience; they can navigate uncertainty and flexibly adapt their responses to meet new and varied circumstances.

Using sensor technology and pattern recognition techniques, AI can identify objects and sounds, track movements, process semantic information and take on robotic behaviors. Through machine-learning routines, robots can be trained to generate perfectly sequenced and accurate responses to high-volume (auditory, visual, tactile, or textual) input. Such systems are part of the Internet of Things (IoT), and can communicate interactively, drive vehicles, diagnose diseases and much more. AI has revolutionized our world and pervades the most routine aspects of everyday life, improving everyday technologies for communities, companies, cities, nonprofit organizations, hospitals, schools, and citizens around the globe.

WORLDWIDE COLLABORATIONS

In May 2021, American software giant PTC entered into a long-term strategic collaboration agreement with the Technion, under which PTC will establish a research and development center and invest approximately $5 million in the Technion's main campus in Haifa. Under the terms of the agreement, PTC and the Technion will jointly research and upgrade learning processes relating to artificial intelligence and advanced manufacturing technology, and PTC will relocate its Haifa development center to the Technion.

Ziv Belfer (left), Divisional Vice President of Global Research and Development and General Manager, PTC; and Prof. Uri Sivan, President of the Technion

From left: PTC's Dr. Michael Reitman and Ziv Belfer; Technion President Prof. Uri Sivan and Prof. Boaz Golany, Executive VP & Director General

PTC is not alone. AI is also at the heart of the Technion's collaboration with several world-class universities: Carnegie Mellon, where the focus is on robotics and AI; Cornell Tech in New York, where the Technion co-directs the Jacobs Technion-Cornell Institute and has AI research collaborations in different fields; and the University of Waterloo in Canada, the Technion's most recent academic joint venture.

Carnegie Mellon houses the largest robotics and AI research enterprise in the world. During the recent COVID-19 pandemic, it became clear that deploying multiple emergency hospitals in multiple locations was the key to managing the crisis. To this end, the Technion and Carnegie Mellon have embarked on a joint project utilizing AI and robotics to create a cooperative human-robot team working together to build hospitals efficiently and effectively. This self-contained system will deploy a team of autonomous robots to automatically build temporary healthcare facilities, anywhere and anytime, on demand. This project will ultimately lead to better and more adaptable solutions to dynamically evolving medical crises.

The AI research group at **Cornell Tech** builds upon decades of AI leadership, and its award-winning researchers are driving discoveries in new AI theories, methods, and applications. Next year, they will run a bilateral course titled "Responsible AI," which will bring together students from Cornell Tech, the Technion, and Tel Aviv University.

The fledgling partnership with the **University of Waterloo** will focus on AI in healthcare, headed by the Technion's Prof. Shai Shen-Orr from the Ruth and Bruce Rappaport Faculty of Medicine. Research teams will apply AI in ways that significantly enhance patient care across a variety of medical conditions.

In addition, the Technion operates in close cooperation with the technology sector in Northern Israel and within its partnership with the prestigious EuroTech Universities Alliance. These partnerships in Israel and worldwide link AI research at the Technion to the vanguard of activity in this field.

ENCOURAGING OUTSTANDING RESEARCH IN AI

Mr. Eric Schmidt, former CEO of Google, has recognized the Technion's leadership position in the field of AI, and generously set up a fund for Career Advancement Chairs in AI through the Schmidt Family Foundation. This fund was set up to invest in talent, encourage outstanding research, and retain exceptional Technion professors in AI. In 2021, the first of six awards went to Prof. Alex Bronstein, Prof. Ronen Talmon, and Prof. Roi Reichart.

Current Career Advancement Chairs in AI are:

- **Prof. Alex Bronstein** of the Henry and Marilyn Taub Faculty of Computer Science studies novel machine-learning techniques that can solve complex challenges in computer vision, and the ways to apply them to various fields, including autonomous vehicles and medical imaging. So far, his lab has extended the depth of field cameras, and built a passive, single-aperture, single-shot depth camera that rivals expensive depth imaging alternatives; designed an upgrade to existing medical ultrasound systems that produces clearer images of fast-moving organs; a faster, higher-quality MRI system; and an affordable, more accurate millimeter-wave radar imaging device. His team is working on endowing drones with "ears" by shaping the aircraft's self-noise for mapping, localization, and navigation.
- **Prof. Ronen Talmon** of the Faculty of Electrical Engineering studies AI by developing new approaches for learning the nonlinear (non-Euclidean) geometries of data. In addition to his lab's theoretical research, his team devises algorithms for real-world AI challenges, for example, the precision and personalization of care of lung and breast cancer patients based on genetic data, the detection of phase transitions in matters based on experimental data observations, the extraction of functional connectivity from biological neural networks, and the prediction of critical conditions of patients in ICUs based on monitoring data.
- **Prof. Roi Reichart** of the Faculty of Industrial Engineering and Management conducts research into Natural Language Processing (NLP), which combines machine learning and artificial intelligence with ideas and methods from the fields of cognition, linguistics, optimization, and statistics to construct computer algorithms that can understand human language. Examples include developing NLP algorithms that can be applied to the wide variety of world languages and predicting human behavior based on verbal communication.

A DEDICATED AI CENTER WITH MORE THAN 100 FACULTY MEMBERS

The Technion boasts a dedicated center for AI research and implementation: The Technion Center for Machine Learning and Intelligent Systems (MLIS), supported by the Zuckerman Fund. The center is co-directed by Profs. **Shie Mannor** and **Assaf Schuster** of the Henry and Marilyn Taub Faculty of Computer Science. It has over 100 affiliated staff members spanning from "core" AI-related faculties (Computer Science, Electrical Engineering, and Industrial Engineering) to "user" faculties (Biomedical Engineering, Mechanical Engineering, and Aerospace Engineering).

MLIS acts as an umbrella and focal point for all Technion AI activities, as well as research collaborations with industrial partners.

MLIS projects are led by the following researchers:

- **Asst. Prof. Ido Kaminer** (Faculty of Electrical and Computer Engineering) designed the Ramanujan Machine, a novel "conjecture generator" that creates mathematical conjectures, which are considered the starting point for developing mathematical theorems.
- **Dr. Or Aleksandrowicz** from the Architectural Research Lab (Faculty of Architecture and Town Planning) led a project based on the collection and analysis of Big Data, using multidisciplinary research related to architecture and urban environments, to support the development of advanced building technologies.
- **Dr. Yaniv Romano** (Faculty of Electrical and Computer Engineering) is leading a machine-learning project focused on design learning and statistical methodologies to effectively identify explanatory features (e.g., genetic variations) linked to a phenomenon under study (e.g., disease risk), while rigorously controlling the number of false positives among the reported features.
- **Asst. Prof. Daniel Soudry** (Faculty of Electrical and Computer Engineering) is carrying out research addressing the core challenges of (1) understanding deep learning and (2) making it more efficient in terms of computational resources.
- **Assoc. Prof. Vadim Indelman's** Autonomous Navigation and Perception Lab (ANPL, Faculty of Aerospace Engineering) investigates problems related to single and multi-robot collaborative autonomous navigation and perception, with a particular focus on accurate and reliable operation in uncertain environments.
- **Prof. Assaf Schuster** is leading the Asynchronous Distributed Training of Deep Neural Networks Project, which has developed asynchronous versions of data-parallel training and showed them to be faster than their synchronous counterparts, contributing to efficient cloud computing.

SPOTLIGHT ON HEALTHCARE

The recent COVID-19 pandemic has clearly demonstrated the lifesaving impact that AI technologies can play in healthcare and medicine, where they have been used from detection to diagnostics. AI is also widely used to improve and personalize treatments of many other diseases and can be found in automated medical diagnostics, remote patient monitoring, surgical robotics, health trackers and intelligent prosthetics.

AI software facilitates the accurate interpretation of medical imaging outputs and the data mining of laboratory information systems to uncover hotspots of infection or endemic disease. It identifies signals in complex molecular patterns, and even drives the bots that schedule follow-up medical appointments and remind us of children's immunization dates. Many of these technologies aim to reduce human error in healthcare provision, accelerate processes or heighten the quality of doctors' face time with patients. Others eliminate the need for invasive procedures or hospitalization.

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HEALTHCARE HIGHLIGHTS

Some of the Technion's many AI successes in the field of healthcare include projects led by the following researchers:

- **Assoc. Prof. Yael Yaniv** (Faculty of Biomedical Engineering) and **Prof. Assaf Schuster** (Taub Faculty of Computer Science) led a joint project to apply advanced deep neural network technology to automatically identify cardiovascular diseases in ECG plots. The results are embedded in a smartphone application to help cardiologists in hospitals with immediate and accurate analysis of ECG, including simple explanations for why the AI-based prognosis is correct.
- **Prof. Shie Mannor** (Faculty of Electrical and Computer Engineering) led a joint project together with the Rappaport Faculty of Medicine and the Rambam Health Care Campus. Medical professionals together with data scientists have developed biofeedback models to encourage physical activity in patients with diabetes and are currently developing a similar biofeedback model for Heparin (a drug used in patients undergoing surgery). This model leads to a better diagnosis and more personalized treatment.
- **Prof. Alon Wolf** (Faculty of Mechanical Engineering) led the development of "Helping Hands" – low-cost, 3D-printed bionic hands for children. **Prof. Alex Bronstein** (Faculty of Computer Science) and student Dean Zadok (whom they jointly mentored) helped develop an algorithm to enable control of the hand and anticipate user intent using ultrasound sensors. This collaborative volunteer initiative to design and fabricate upper-limb assistive technology devices has made the market for artificial limbs much more accessible and affordable.
- **Prof. Wolf** also set up the Biorobotics and Biomechanics Lab (BRML), which encompasses various research areas. Using deep learning methods to study the mechanics of the body with a focus on rehabilitation, they have developed patient-specific methods to improve the motor function of healthy and disabled people, thus making treatment more personalized and individual. Furthermore, the lab has created many types of robots, which can be taught to respond and move in more nuanced and responsive ways. These robots are being used for surgery and for rescue and recovery missions.
- **Prof. Wolf and Prof. Ron Kimmel** (Faculty of Computer Science), together with their Ph.D. student Benjamin Groisser, created a radiation-free diagnostic and assessment system for scoliosis in children and adults, in partnership with the Hospital for Special Surgery (HSS) in New York. The diagnostic is performed by implementing machine vision and AI algorithms on a large and unique data set, collected at HSS.
- **Dr. Gil Shamai and Prof. Ron Kimmel** (Faculty of Computer Science) have developed the Technion's "computerized pathologist," which uses AI and Big Data to decode the unique signatures of certain cancer cells and improve personalized medicine. With the help of image processing and AI tools, researchers can predict the molecular profile of cancerous cells just by looking at the tissue as it appears on standard biopsy scans.
- **Prof. Kimmel** is also conducting research with the Technion's **Prof. Tzipi Horowitz-Kraus** (Faculty of Education in Science and Technology) on a project called ZoomEmotion. They are developing an algorithm that detects the emotional state of the child in real time by reading their facial expressions, and signals to the teacher when the child is experiencing a negative emotion.

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FIGHTING COVID-19

These are some of the researchers who are leading the Technion's AI successes in fighting COVID-19:

- **Prof. Hossam Haick** (Wolfson Faculty of Chemical Engineering) recently developed a diagnostic test for pre-symptomatic COVID-19 carriers. He previously developed a nano-artificial nose for detecting cancer and other diseases. The innovative electronic 'nose' can smell 17 diseases on a person's breath, including Alzheimer's, Parkinson's, tuberculosis, diabetes, and lung cancer.

- **Prof. Roy Kishony's** laboratory (Faculty of Biology) has carried out research analyzing the data of thousands of patients to show the effectiveness of the COVID-19 vaccine. This was done in collaboration with Israeli healthcare service provider Maccabi. The results demonstrated reduced viral load and transmission of those vaccinated. Prof. Kishony has also developed an algorithm based on research into antibiotic resistance, which reduces by half the risk of prescribing the wrong antibiotics to patients.

- **Assoc. Prof. Roee Amit** (Faculty of Biotechnology and Food Engineering) has led research into machine learning for antiviral drugs, which aims to develop antivirals in similar quantity, variety, and effectiveness as antibiotics. His team demonstrated that a combined synthetic biology and machine learning approach can result in the discovery of molecules that can bind proteins from two distinct viruses.

- **Dr. Kira Radinsky** (Technion alumna) and her startup Diagnostic Robotics – which she co-founded with Technion **Professor Emeritus Moshe Shoham** (Faculty of Mechanical Engineering) and alumnus **Yonatan Amir** – have been instrumental in fighting COVID-19 by predicting its spread around the globe using AI technologies. An esteemed data scientist and visiting Technion professor, Dr. Radinsky gained recognition after predicting the cholera outbreak in Cuba a few years ago.

DIVERSE FIELDS OF AI RESEARCH

In addition to its significant contribution to healthcare in general, and specifically in the fight against COVID-19, artificial intelligence has been at the heart of research in a wide variety of fields at the Technion, including transportation, FinTech, AgriTech, and others.

AUTONOMOUS SYSTEMS AND VEHICLES

- Since 2007, the Technion has been carrying out research on autonomous vehicles for land, sea, air, and space as part of the Technion Autonomous Systems Program (TASP), under the leadership of **Distinguished Prof. Emeritus Daniel Weihs** (Faculty of Aerospace Engineering). TASP is a multi-departmental and multidisciplinary unit, and the first of its kind in Israel. The unit is home to Technion faculty members from nine different departments and has developed a wealth of intelligent systems, applications and implementations that will drive progress in defense, medicine, and industry. TASP also offers specialized graduate degrees in unmanned vehicles.

- The Israeli Ministry of Transportation is currently collaborating with the Technion to develop a simulator that will ensure AV safety prior to operating on public roads.

- Roving vehicles that look for hidden or parked vehicles – led by **Assoc. Prof. Vadim Indelman.**

ROBOTICS

- Researchers at the Technion, together with Israeli chipmaker TowerJazz, developed a revolutionary technology that transforms a commercial flash memory chip into a device that contains both memory and computing ability, boosting computer power for artificial intelligence needs.

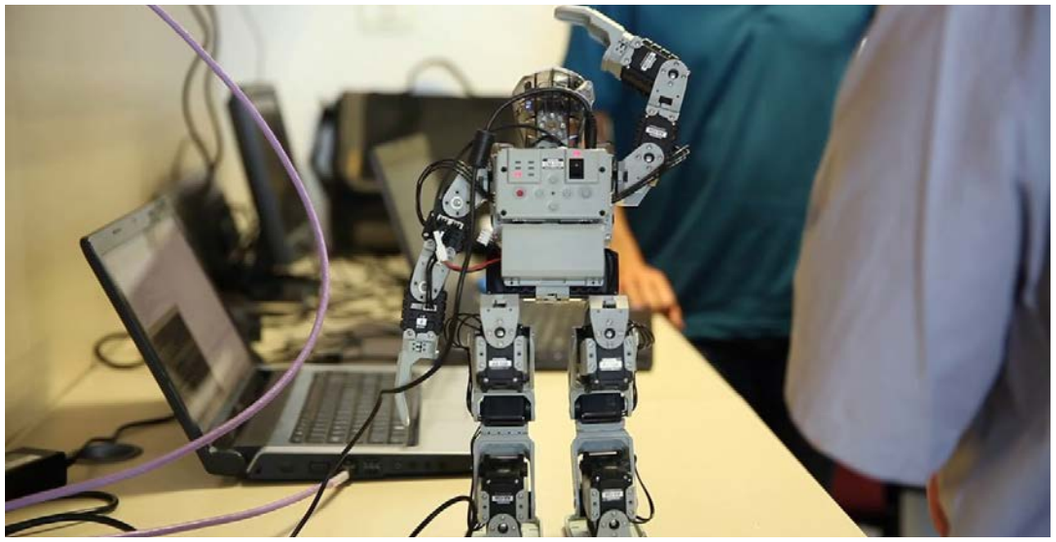
- As previously mentioned, the Technion has had a long academic relationship with Carnegie Mellon University (including current joint research), whose Robotics Institute is an international leader in robotics education. The world's first Robotics PhD program was founded there in 1988, with the goal of providing graduate students with the knowledge, experience, and skills to become the next leaders in robotics research and education.

- Announced in 2014, the initial agreement between PTC jumpstarted a robotics and digital content program, including a teaching laboratory for industrial IoT, computer-aided design, manufacturing, and augmented reality, among other STEM topics. As a result of the long-standing collaboration, Technion alumni have joined PTC to lead the company's Haifa development center, PTC's second-largest center outside the U.S., which will soon relocate to the Technion City as a result of the 2021 agreement.

- Technion researchers at the Faculty of Computer Science are developing software and systems to implement and protect IoT systems, embedding sensors, actuators, displays, and computational elements in everyday objects that are connected through a continuous network to create smart environments.

- Development of a mobile robot with storage and dispensing capabilities to serve large organizations (e.g., hospitals, factories, multi-building corporations and campuses) that require efficient mechanisms for reliably transferring small items such as medicines, supplies, packages, paperwork, and devices.

- Development of Cobots – under the guidance of Asst. Prof. Erez Karpas and Dr. Shlomi Laufer (Faculty of Industrial Engineering and Management). The dedicated robotics lab is designed to be flexible enough to simulate both an industrial setting (factory, warehouse) and a service robotics setting (smart home, hospital) by using multipurpose robots, modular furniture, and an open space design. Prof. Karpas and his student Yotam Amitai recently published a paper on automatically generating a flexible plan for human-robot teamwork. The key idea is to generate multiple diverse plans and then merge them into one flexible plan with choices, which generalizes all the constituent plans.



FINTECH AND AGRITECH

FinTech

- Since 2019, the Technion has run a FinTech (financial technology) program strongly linked to the banking sector. Its eight courses can be broadly divided into two tracks: machine learning (AI) and probability; and algotrading, portfolio management and corporate risk. The programs are run in partnership with DRW Israel and the First International Bank of Israel.
- In April 2021, four Technion students from the Faculty of Industrial Engineering and Management won first place in a FinTech hackathon sponsored by the Bank of Jerusalem and Malam Tim Group, for presenting their technological solutions to financial challenges. This achievement is a testament to the Technion's excellence in FinTech.

AgriTech

Research is underway at the Technion's Civil, Environmental, and Agricultural Robotics Lab (CEAR) on various autonomous agricultural robots:

- A small tractor equipped with soil analysis systems, which operates together with a drone that collects the samples and delivers them to the tractor for analysis and then uploads data to the cloud. Adjustments to irrigation, fertilizers, pesticides, etc. can then be made automatically, conserving water and other resources.
- The design of autonomous robotic pollinators to address the problems caused by the collapse of bee colonies.
- Prof. Ron Kimmel's team has developed smart technology for the monitoring and prediction of crop stress and leaf segmentation.

AI COMPANIES FOUNDED BY TECHNION FACULTY AND ALUMNI

- Three Technion graduates founded Cortica, one of the leading companies in autonomous AI. Cortica's chief scientist and co-inventor is Technion **Prof. Yehoshua (Josh) Zeevi;** the other two co-founders are **Karina Odinaev** and **Igal Raichelgauz.**

- **Profs. Alex Bronstein and Michael Bronstein,** together with **Prof. Ron Kimmel,** developed 3D sensor technology and later founded InVision Biometrics (facial recognition technology for gaming), which made 3D sensor printed circuit boards (PCBs) that detect face and body movements and translate them into on-screen game moves. The company was acquired by Intel in 2011. **Prof. Michael Bronstein** has also done groundbreaking work on AI-designed hyperfoods. **Prof. Ron Kimmel** is also the founder of the Geometric Image Processing Lab and a founder and advisor of several successful image processing and analysis companies.

- **Prof. Shai Shen-Orr's** research laid the foundation for CytoReason - a company developing a computational model of the human body accurate enough to replace animal and human trials in drug development. To date, it is used by six of the world's top 10 pharma companies, including Pfizer, using computers instead of animals to model the human immune system.

- **Yael Vizel**, CEO of Zeekit, took her extensive experience in developing real-time image processing technologies, computer vision, deep learning, and artificial intelligence to implement them in the world of fashion. Vizel, together with her Zeekit co-founders, developed the first dynamic virtual fitting room, mapping a person's image into thousands of segments and giving every person the chance to see themselves in any item of clothing found online. Retail giant Walmart recently acquired Zeekit for an undisclosed amount.

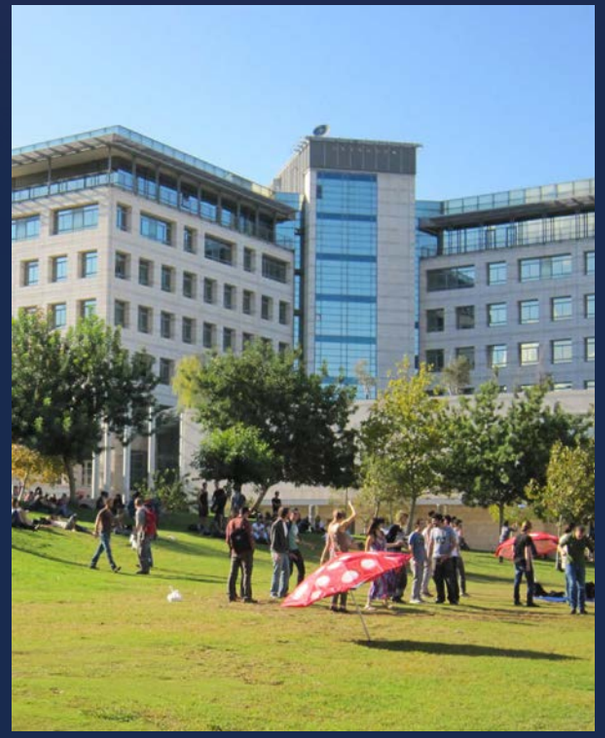
- **Prof. Naama Geva-Zatorsky** co-founded Biotax, which offers biological and genomic informatics solutions for pharma companies, hospitals, and medical centers. The startup was founded by a group of leading researchers whose mission is to help patients by creating new diagnostics and treatment protocols.

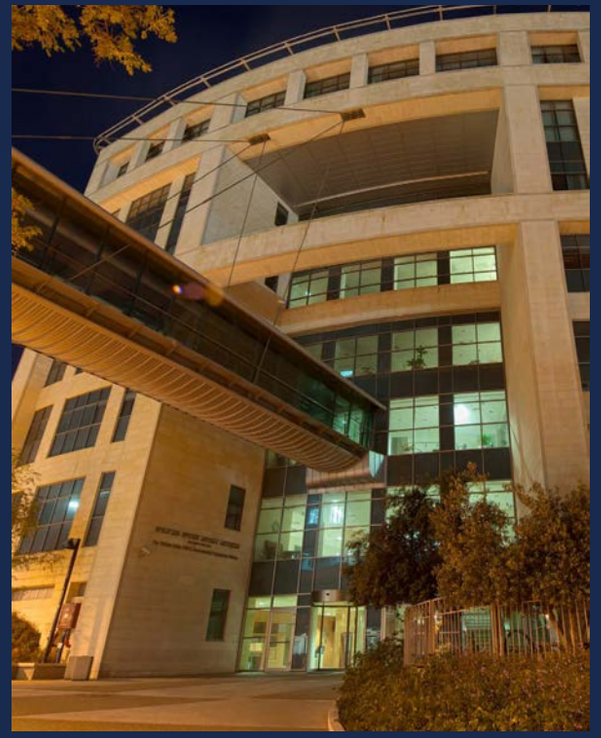
- **Prof. Ran El-Yaniv** is co-founder and chief scientist of Deci.AI – a startup involved in deep learning acceleration. Their mission is to enable AI developers and engineers to solve the world's most complex problems - enabling machine learning and deep learning models to fully perform in production and fulfill their true potential.

- **Dr. Jonathan Abir** and **Dr. Arie Abir** co-founded AD Knight, which provides novel solutions to help save pedestrians' lives based on personal device detection systems such as Bluetooth, Wi-Fi, and Cellular. In 2019 the company was accepted into the Technion DRIVE Accelerator Program.

AI COURSES AT THE TECHNION

A variety of departments at the Technion offer over 50 AI-related courses, each emphasizing a different aspect. These courses are taken by more than 1,000 students annually, and include:





- **Computer Science:**
  - Introduction to Artificial Intelligence
  - Introduction to Learning Systems
  - Deep Learning on Computational Accelerators
  - Image and Information Signal Processing
  - Artificial Intelligence Project
  - Intelligent Systems
  - Advanced Topics in Deep Learning
  - Introduction to Robotics
  - Natural Language Processing (NLP)

- **Mechanical Engineering:**
  - Neural Network for Control and Diagnostics
  - Analytic and Machine Learning-Based Modeling Systems

- **Biomedical Engineering:**
  - Machine Learning in Healthcare
  - Deep Learning Applications in MRI
  - Analysis of Biological Signals
  - Medical Image Processing (Biomedical)

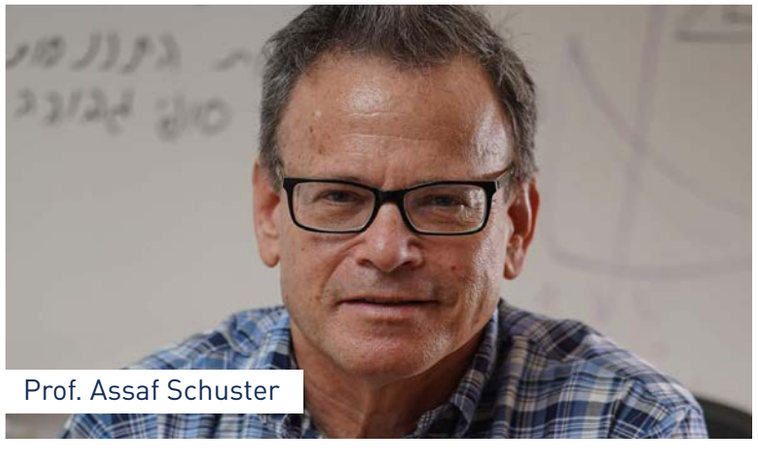
- **Industrial Engineering:**
  - Artificial Intelligence and Autonomous Systems
  - Interactive Intelligent Systems
  - Artificial Intelligence in Distributed Environments

AI AT THE TECHNION IN PICTURES

Prof. Naama Geva-Zatorsky

Prof. Roee Amit

Prof. Ron Kimmel


Prof. Assaf Schuster

Prof. Shai Shen-Orr

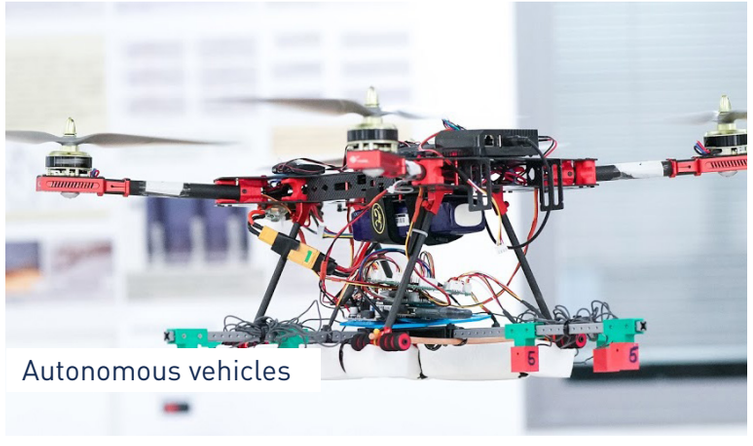
Prof. Hossam Haick

AI AT THE TECHNION IN PICTURES

Prof. Tzipi Horowitz-Kraus

Prof. Shie Mannor

Prof. Erez Karpas



Autonomous vehicles

Prof. Alon Wolf

Robotics