ARTIFICIAL INTELLIGENCE (AI) AT BGU

2021

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

BGN Ltd
Of Ben-Gurion University

ARTIFICIAL INTELLIGENCE (AI) RESEARCH AT BGU

ARTIFICIAL INTELLIGENCE AT BEN-GURION UNIVERSITY

Artificial intelligence (AI), the ability to program computers to perform human-like tasks, is increasingly becoming an integral part of almost every aspect of modern life. Applications as diverse as Google maps, face detection and recognition, e-payments and social media platforms, all rely on AI, and AI is becoming more and more widespread as a solution for practical problems in an ever-growing range of discipline and activities.

Here at Ben-Gurion University, we take pride in cultivating extensive, interdisciplinary AI research activities. In this booklet we will try to shed light on some of the breakthrough AI advances at BGU that encompass multiple and diverse fields of research, including medical applications, robotics, cyber security, finance, linguistics, computer vision and more.

BGN Technologies, the technology transfer company of Ben-Gurion University, supports BGU's groundbreaking AI applications though promoting collaborations between academia and the industry, and advancing the development and commercialization of AI-based technologies.

Zafrir Levy
Senior VP, Exact Sciences & Engineering

CONTROL OF MIXED PLATOONS

RELEVANT PUBLICATIONS

O. Orki, S. Arogeti, "Control of Mixed Platoons Consist of Automated and Manual vehicles", in the Proceedings of 2019 IEEE International Conference on Connected Vehicles and Expo (ICCVE), Nov. 2019

Dr. Shai Arogeti and **Omer Orki**
arogeti@bgu.ac.il

Department of Mechanical Engineering

Expertise
Automotive control systems

Objectives

Platooning has a great potential for improving highway traffic flow. Platooning research focuses on fully automated platoons. However, in the near future traffic will be mixed and will consist of automated and manually driven vehicles.

Our study introduces a new concept of mixed platoons, i.e., platoons consisting of automated and manually-driven vehicles. In a mixed platoon the automated vehicles are controlled as part of the mixed traffic, using global sight on traffic. Thus, the mixed traffic flow can be optimized using the automated vehicles. The mixed platoon controller implements the same control components that are used for automated platoons, but modifies them to suit a mixed traffic environment. In particular, we suggest a new Information Flow Topology (IFT) and a Distributed Controller (DC) for mixed platoons using H-infinity control principles.

Additionally, machine learning techniques are incorporated to compensate for the uncertain human driver behavior. The main goal is to improve traffic flow in mixed traffic environments.

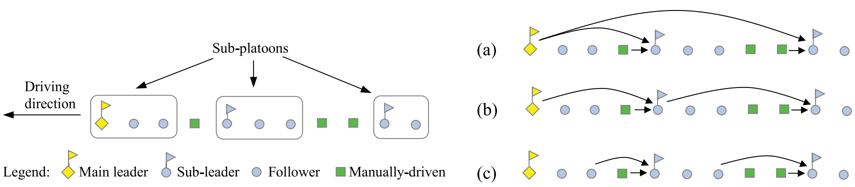

Fig. 1. Division of one mixed-platoon into sub-platoons

Fig. 2. A demonstration of the three types of inter sub-platoon IFTs for mixed platoons.

Mixed-platoon configuration

Description

The mixed platoon is divided into fully automated sub-platoons, where each sub-platoon is separated by one or more manually-driven vehicles. Only sub-leaders are responsible for receiving information from outside the sub-platoon. Sub-leaders also interact with human drivers, hence their onboard sensors collect the information needed to learn the human drivers' behavior. Sub-leaders serve as the adhesive, which makes a collection of sub-platoons separated by human drivers a unified system with desired traffic flow performance.

Applications & Products

Smart roads, traffic control, advanced driver-assistance systems (ADAS)

DEEP LEARNING FOR IMPROVED PERCEPTION

RELEVANT PUBLICATIONS

Please see:
https://scholar.google.com/citations?user=x4GlT3IAAAAJ&hl=en

Dr. Aharon Bar-Hillel, Senior Lecturer
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Department of Industrial Engineering and Management

Expertise
Computer vision and machine learning

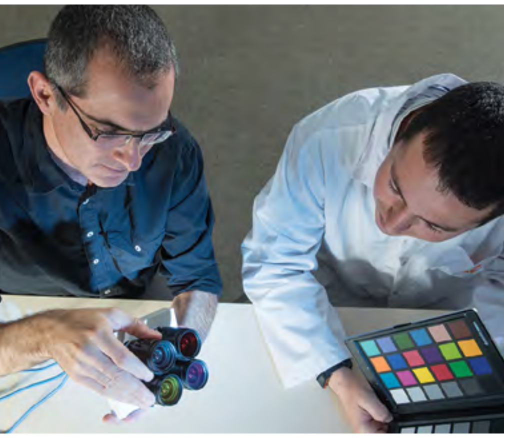
Objectives
A machine learning and computer vision researcher. In recent years, my work focuses mostly on deep learning methods.

Description
- Visual discrimination problems in agricultural settings
- Acceleration and interpretation of deep networks
- Adaptive and flexible robotic assembly
- Networks for inverse problems in ultrasound processing
- Visual tracking, visual pose estimation
- Predicting peptide-MHC to T-Cell Receptor (TCR) connections

COMPUTATIONAL AND COMPUTER VISION

RELEVANT PUBLICATIONS

Please see:
https://www.cs.bgu.ac.il/~ben-shahar/publicbyy.html



Prof. Ohad Ben-Shahar
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https://www.cs.bgu.ac.il/~ben-shahar

Department of Computer Science

Expertise
Computational vision

Objectives
Prof. Ben-Shahar's research focuses on computational vision, with interests that span all aspects of theoretical, experimental, and applied vision sciences and their relationship to cognitive science, as a whole. He is the founding director of the interdisciplinary Computational Vision Laboratory (iCVL), where research involves theoretical computational vision, human perception and visual psychophysics, visual computational neuroscience, animal vision, applied computer vision, and (often biologically inspired) robot vision.

Description
Prof Ben-Shahar is the principle investigator in numerous research activities, from basic research in animal vision projects through applied computer vision, data sciences, and robotics consortia. Recent and ongoing projects include:

- Automatic visual puzzle solving for real life applications (like archeology)
- Hyperspectral imaging and vision
- Completion of missing visual information
- Visual biometrics and forensics (including deep fake detection)
- Eye tracking and visual saliency prediction and analysis
- Vision for physical therapy
- Agrovision and Agrobotics: Computer vision and robotics for agricultural applications

Applications & Products
Prof. Ben-Shahar was the co-founder of HC-Vision, a BGU spinoff startup established in 2016, which combines computational vision and data science tools to allow conventional RGB or multi-spectral camera sensors to acquire hyperspectral images for a wide range of applications, such as low-light photography, superior color capturing, superior image-based biometrics, and material sensing.

ENGINEERING INTELLIGENT SYSTEMS CAPABLE OF DEXTEROUS MOTION

Prof. Sigal Berman
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Department of Industrial Engineering and Management

Expertise
Robotics, motor control

Objectives
The Intelligent Systems Engineering Laboratory (ISEL) at the Department of Industrial Engineering and Management focuses on the analysis and engineering of intelligent systems capable of dexterous motion. We develop deterministic and stochastic models for the synthesis of robotic motion and for the analysis of human motion. We design and build intelligent, integrated systems capable of dexterous motion in various application fields (e.g., agriculture, rehabilitation, and the digital factory). We study the interaction between perception and action in physical, virtual, and augmented environments.

Description
- Agriculture: We are developing advanced robotic precision agricultural systems with sensor fusion and data analysis capabilities, which will enhance both production yield and sustainability.
- Upper-limb rehabilitation: We are developing robotic and virtual reality-based systems for advancing functional recovery following stroke, based on advanced motor control theories.
- The digital factory: we are developing cyber-physical systems capable of learning and adaptation based on user intent identification, implementing Industrial Internet of Things (IIoT) concepts.

Applications & Products
Selected projects:
- Upper limb treatment for stroke rehabilitation
- Perception and action in remote and virtual environments
- A robot for Mejdool-date thinning
- AVR4Nano: Acoustic-visual mobile robotic manipulator for application of nanostructures in agriculture

RELEVANT PUBLICATIONS

I. Davitowitz, Y. Parmet, M. C. Baniña, S. Frenkel-Toledo, N. Soroker, J. M. Solomon, D. G. Liebermann, M. F. Levin, **S. Berman,** 2019. Effects of spasticity on upper limb movement in patients with stroke using stochastic spatiotemporal modeling, *Neurorehabilitation and Neural Repair*, 33(2):141–152

N. Schor, A. Bechar, T. Ignat, A. Dombrovsky, Y. Elad, and **S. Berman,** 2016, Robotic disease detection in greenhouses: combined detection of Powdery Mildew and Tomato Spotted Wilt Virus, *IEEE Robotics and Automation Letters (RA-L) (and ICRA),* 1(1):354-360.

O. Mendels, H. Stern, and **S. Berman,** 2014. User identification for home entertainment based on free-air hand motion signatures, *IEEE Transactions on Systems Man and Cybernetics: Systems,* 44(11):1461-1473.

D. Frolova, H. Stern, and **S. Berman,** 2012. Most probable longest common subsequence for recognition of gesture character input, *IEEE Transactions on Systems Man and Cybernetics, part B,* 43(3): 871-880.

RELEVANT PUBLICATIONS

Please see:
http://armin-biess.net/publications/

ROBOT LEARNING

Dr. Armin Biess
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Department of Industrial Engineering and Management

Expertise
Robotics, learning agents, machine learning, reinforcement learning

Objectives
In the last ten years there have been significant breakthroughs in machine learning, resulting in super-human accuracy for image classification and object detection, as well as major advances in natural language processing. The development of intelligent robots, however, which can learn a broad range of tasks in a variety of real world environments, has been less affected by this revolution and poses still huge computational and algorithmic challenges. In the field of robot learning, we investigate methods of how robots can efficiently learn novel tasks and adapt to different, often unknown, environments. As learning is a major aspect of intelligence we can consider learning in robots as *embodied* AI.

Description
Our research focus is on skill learning in robots and learning agents in general and the development of systems that can act autonomously in uncertain and unstructured environments. Toward this goal, we study different perceptual-motor learning tasks on various robotic platforms (humanoids, manipulators, and mobile robots) in simulations and in reality, and we use methods from robotics and machine learning; in particular, reinforcement, imitation, and deep learning. To enable learning, we combine data-driven approaches with model-based formulations and explore the mathematical structure of intelligent systems acting in a complex environment in terms of geometry, optimal control, and probability theory. One major objective of our research is to apply reinforcement learning methods in the real world. Since human capabilities are far beyond those of artificial systems, we try to gain further insights into the development of intelligent systems from studies in human motor control, biomimetics, neuroscience, and psychology.

Applications & Products
- Intelligent robots
- Learning agents
- Mathematics for intelligent systems

DEEP LEARNING FOR COGNITIVE RADAR

Dr. Igal Bilik, Senior Lecturer
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Department of Electrical and Computer Engineering

Expertise
Sensing for autonomous systems

Objectives
The main objective of our research is development of cognitive radar approaches using artificial intelligence and deep learning methods. The underlying idea is to mimic bio-inspired sensing (e.g., bats) by introducing learning capabilities into the radar systems. Our research leverages recent progress with deep learning in computer vision and introduces deep learning methods into radar signal processing domain.

Description
Our research seeks to use artificial intelligence to address the following radar tasks:

- Radar target classification by using deep learning methods. Our work focuses on the DNN architecture development that is best suited for complex radar data in the 4D domain of range-Azimuth-Elevation-Doppler.
- Data deficient training in radar processing. Data collection and annotation is an extremely complex and time-consuming task, significantly more challenging than computer vision). Therefore, availability of large and complete training data sets is the major obstacle to using the DNN approach in radar signal processing. Our research addresses this challenge by using physical information on radar target locomotion for data augmentation.
- Use of DNN to study the non-Gaussian nature of radar clutter and thus, to dramatically improve probability of target detection.
- Radar angular resolution is determined by the antenna aperture. Therefore, a large number of antenna array elements is required for imaging radar implementation (e.g. in automotive radars). Unfortunately, a large number of transmit or receive channels interconnected to the antenna elements makes the cost of the system prohibitively high. Our research develops the antenna selection approach, where a small number of radar channels is sequentially connected to a large number of array elements by using the DNN approach in the learning stage.

RELEVANT PUBLICATIONS

Please see:
https://dblp.uni-trier.de/pers/hd/b/Brafman:Ronen_I=

AUTOMATED DECISION MAKING & AUTONOMY

Prof. Ronen Brafman
brafman@cs.bgu.ac.il

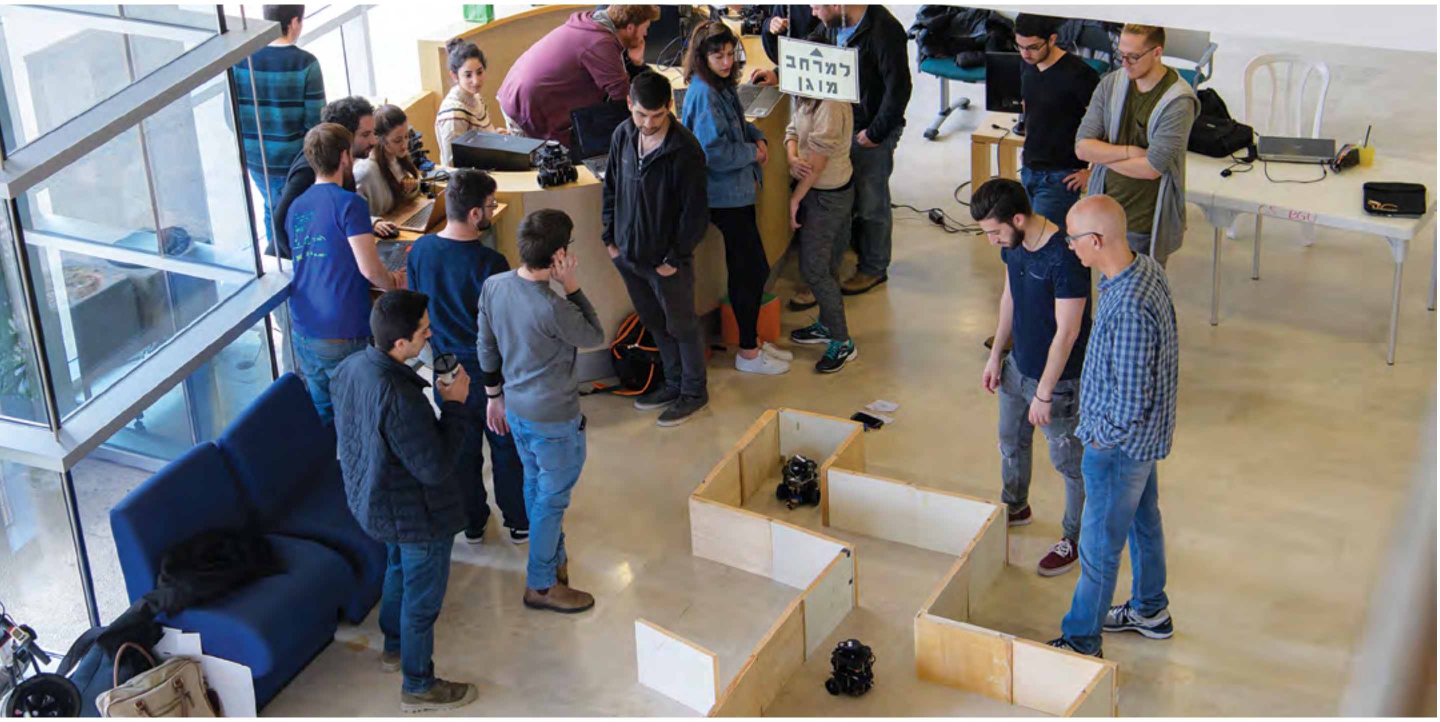
Department of Computer Science

Expertise
Automated planning, multi-agent planning, autonomous robotics

Objectives
My work focuses on diverse techniques for helping create systems that can make decisions and act on their own in order to achieve their goals, thus enhancing their level of autonomy, as well as building systems that support human decision-making. This work spans areas such as classical and decision-theoretic planning and decision-making, preference modeling and preference elicitation, preference-based optimization, agent models, multi-agent and distributed planning, privacy preserving planning, and autonomous robotics.

Description
My work focuses on the area of artificial intelligence, and in particular, automated planning and decision making, decision automation, distributed and multi-agent planning, process automation, and task monitoring. In all these areas we seek to enable a system (or an agent) to perform some of its tasks in an automatic or autonomous manner.

Applications & Products
Autonomous robots



HUMAN-CENTERED ARTIFICIAL INTELLIGENCE

Dr. Jessica Cauchard
cauchard@bgu.ac.il

Department of Industrial Engineering and Management

Expertise
Human-computer interaction, robotics

Objectives
My research explores the design, development, and evaluation of human-centered intelligence systems. In particular, my work investigates how future technologies will better support people by designing usable technologies. By leveraging Artificial Intelligence and Machine Learning techniques, we guide and study future technologies and applications that are aware of their users and context.

Artificial Intelligence offers tremendous potential for a better future. As AI gets introduced all around us in support of humans, it is crucial to design and create systems that have a true understanding of people, including our behaviors, intentions, emotions, and feelings. To achieve this, the designers and programmers of AI need multidisciplinarity and broad thinking.

Description
My research spans across all types of mobile technologies, whether autonomous or user controlled. Some of the research investigates the design of novel technologies and sensors, while other projects focus on the impact of AI-driven technologies on users over time for a wide range of applications.

Applications & Products
- Mobile and wearable devices
- Autonomous systems
- Robots and UAVs
- Internet of things
- Physiological computing
- Emotional computing
- Wellbeing

RELEVANT PUBLICATIONS

Frey J., Ostrin G., Grabli M., and **Cauchard J.R.** 2020. Physiologically Driven Storytelling: Concept and Software Tool. In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (CHI '20). Association for Computing Machinery, New York, NY, USA. DOI:https://doi.org/10.1145/3313831.3376643

Wojciechowska A., Frey J., Mandelblum E., Amichai-Hamburger Y., and **Cauchard J.R.** 2019. Designing Drones: Factors and Characteristics Influencing the Perception of Flying Robots. Proc. ACM Interact. Mob. Wearable Ubiquitous Technol. 3, 3, Article 111 (September 2019). DOI:https://doi.org/10.1145/3351269

Frey J., Grabli M., Slyper R., **Cauchard J.R.** 2018. Breeze: Sharing Biofeedback through Wearable Technologies. In Proc. of the 2018 ACM Conference on Human Factors in Computing Systems (CHI '18). DOI: https://doi.org/10.1145/3173574.3174219

ONLINE LEARNING AND INFERENCE IN COMPLEX SYSTEMS

Dr. Kobi Cohen, Senior Lecturer
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Department of Electrical and Computer Engineering

Expertise
Statistical inference, machine learning, AI, stochastic optimization

Objectives
We are interesting in developing novel algorithmic solutions for real-world problems in the fields of online learning, anomaly detection and AI, with analysis and applications in communication networks, cyber-security, and large-scale systems. The focus is both on applicative aspects for real-world production environments, as well as solid theoretical foundations for performance guarantees.

Description
Statistical inference and learning in high dimension are particularly relevant in the era of large-scale networks and the abundance of data. Our current research projects include searching for rare events, active federated learning and inference (Israel Science Foundation), AI-based spectrum access, AI-based network scheduling (Israel Ministry of Economy), AI-based anomaly detection (Israel National Cyber Bureau via the BGU Cyber Security Research Center), as well collaborative research projects with industrial partners such as IBM, RAFAEL, and others.

Applications & Products
Efficient solutions to a broad range of emerging applications, such as communications and infrastructure systems, 5G, IoT, anomaly detection and cybersecurity.

RELEVANT PUBLICATIONS

Tomer Sery and **Kobi Cohen**, “On analog gradient descent learning over multiple access fading channels,” IEEE Transactions on Signal Proccessing, 2020.

Oshri Naparstek and **Kobi Cohen**, “Deep multi-user reinforcement learning for distributed dynamic spectrum access,” IEEE Transactions on Wireless Communications, 2019.

Kobi Cohen and Qing Zhao, “Active hypothesis testing for anomaly detection,” IEEE Transactions on Information Theory, 2015.

CONCISE BIG DATA REPRESENTATIONS FOR MACHINE LEARNING

Prof. Shlomi Dolev
dolev@cs.bgu.ac.il

Department of Computer Science

Expertise
Big data

Objectives
- NoiseReduction: purify data to be able to define better features
- ThirdLife: building a virtual physiological social laboratory
- MLDStore: enable organizations to use, buy, and sell BigData services

Description
- NoiseReduction: Use the essence of code, i.e., opcode, eliminating noisy information for better use of machine learning for identifying security threats.
- ThirdLife: build avatars/bots for persons and let the avatars interact to indicate the effect of social interactions in a team.
- MLDStore: Machine learning is based on historical (big) data for training. The collected big data is hard to handle, store, and process. Thus, there is a need for keeping small data with the essence of Big Data; small data that can later be used for training instead of huge Big Data. Such an approach will allow efficiency in storage, processing, and masking (for privacy reasons) the actual raw data, while keeping the needed statistical information.

Applications & Products
- NoiseReduction: patented by Deutsche Telekom as part of malicious code identification
- ThirdLife: research, development, and implementation, recently started
- MLDStore: prototypes exist, pitched in front of investors

RELEVANT PUBLICATIONS

Philip Derbeko, **Shlomi Dolev**, Ehud Gudes. Deep Neural Networks as Similitude Models for Sharing Big Data. *BigData* 2019: 5728-5736.

Philip Derbeko, **Shlomi Dolev**, Ehud Gudes. MLDStore - DNNs as Similitude Models for Sharing Big Data (Brief Announcement). *CSCML* 2019: 93-96.

Philip Derbeko, **Shlomi Dolev**, Ehud Gudes. Privacy via Maintaining Small Similitude Data for Big Data Statistical Representation. *CSCML* 2018: 105-119 2017.

Philip Derbeko, **Shlomi Dolev**, Ehud Gudes, Jeffrey D. Ullman. Efficient and private approximations of distributed databases calculations. *BigData* 2017: 4487-4496.

INTELLIGENT ROBOTICS LAB

RELEVANT PUBLICATIONS

Please see:
https://smartrobabcbgu.wixsite.com/iemirl/publications

Prof. Yael Edan
yael@bgu.ac.il
https://smartrobabcbgu.wixsite.com/iemirl

Department of Industrial Engineering and Management

Expertise
Robotics: human-robot collaboration, agricultural robotics (sensing, systems engineering).
Intelligent automation systems (decision support systems, evaluation, simulation, multi sensors, and robots).

Objectives
Development and application of intelligent automation (sensors, algorithms and control) and industrial engineering techniques (performance measurement, simulation, systems engineering).

Multidisciplinary application-oriented R&D: dive into unknown domains, learn the scope and terminology, identify the problems, apply or develop advanced technology/algorithms and come out with a product or system that works.

Advance intelligent automation in agriculture.

Description
- Human-robot collaboration:
  - Models for human-robot collaboration
  - Human-robot cooperative learning
  - Interface & interaction design: design methods, intelligent interfaces, evaluation methods
- Agriculture robotics:
  - Systems engineering
  - Intelligent sensing & planning
- Robotics: performance measurement, systems engineering, simulation modeling, sensing & planning
- Intelligent automation systems: sensing, simulation, evaluation

Applications & Products
- Robotics:
  - Assistive and social robotics
  - Collaborative robotics
  - Agricultural Robotics
- Intelligent Automation Systems:
  - Agriculture sorting systems, phenomics, dairy automation
  - Multi-sensor systems for industrial applications
  - Technologies for older adults and physical therapy

ABC ROBOTICS INITIATIVE

https://in.bgu.ac.il/en/robotics/Pages/default.aspx

abc-robotics@bgu.ac.il

The ABC Robotics Initiative aims to advance innovative multidisciplinary robotics research at BGU in the domains of agricultural, biological and cognitive robotics.

The ABC Robotics Initiative is driven by a vision and a commitment for collaboration and interdisciplinary research. By bringing together senior and junior researchers from different disciplines, such as robotics, computer sciences, cognitive sciences, neurosciences, biopsychology and physiology, we aim to spark new ideas and research directions.

Multidisciplinary R&D teams have been established and are contributing to the development of agricultural, biological and cognitive robotics by advancing theoretical foundations, practical applications, and innovative designs.

Research activities include monthly seminars, research development projects and international and graduate fellows.

abc

agricultural biological & cognitive robotics

COMPUTER VISION AND MACHINE LEARNING

Prof. Jihad El-Sana
el-sana@cs.bgu.ac.il

Department of Computer Science

Objectives
Prof. El-Sana's recent research focuses on:
- Analyzing video streams: Developing machine-learning based algorithms for semantic segmentation, and object detection & extraction from images and videos.
- Augmented reality: Investigating the utilization of augmented reality interfaces for manipulating CAD models, which are the core of human-made machines.
- Document image analysis: Designing algorithmic tools for processing document images, includeing page layout analysis, scribe style classification, word spotting, and text identification.

Description
Prof. Jihad El-Sana's research interests include document image analysis, image processing, computer graphics, augmented reality, and computer vision. El-Sana is the head of the Department's Visual Media Laboratory (VML), which hosts various research projects in visual computing with applications of machine learning.

Applications & Products
- Semi-automatic processing of historical documents in Arabic and Hebrew
- Detecting and extracting advertisements from video streams
- Augmented reality for the manipulation of CAD models

HEURISTIC SEARCH IN ARTIFICIAL INTELLIGENCE

Prof. Ariel Felner
felner@bgu.ac.il

Department of Software and Information Systems Engineering

Expertise
Artificial intelligence

Objectives
My main field of research is heuristic search in artificial intelligence. I am interested in all aspects of heuristic search, including theoretical foundations, new search algorithms, the study and development of heuristics, and I apply all these aspects to different domains and settings.

Special focus of recent research has been given to the multi-agent path finding problem that can be expressed as a single-agent search problem, and other settings. Recently, together with colleagues, we have started in a new research direction that tries to understand the nature of bidirectional search.

Description
In heuristic search, we are given a description of a state-space and the task is to find (the shortest) paths from an initial state to a goal state. We use intelligent heuristics to guide the search that finds such a solution as fast as possible.

Applications & Products
I have applied heuristic search to many real-world problems, such as combinatorial puzzles, road path finding, and others.

RELEVANT PUBLICATIONS

Ariel Felner: Position Paper: Using Early Goal Test in A. SOCS 2018: 153-157

Ariel Felner, Roni Stern, Solomon Eyal Shimony, Eli Boyarski, Meir Goldenberg, Guni Sharon, Nathan R. Sturtevant, Glenn Wagner, Pavel Surynek: Search-Based Optimal Solvers for the Multi-Agent Pathfinding Problem: Summary and Challenges. SOCS 2017: 29-37

Robert C. Holte, **Ariel Felner,** Guni Sharon, Nathan R. Sturtevant, Jingwei Chen: MM: A bidirectional search algorithm that is guaranteed to meet in the middle. Artif. Intell. 252: 232-266 (2017)

Guni Sharon, Roni Stern , **Ariel Felner,** Nathan R. Sturtevant: Conflict-based search for optimal multi-agent pathfinding. Artif. Intell. 219: 40-66 (2015)

Ariel Felner, Uzi Zahavi, Robert Holte, Jonathan Schaeffer, Nathan R. Sturtevant, Zhifu Zhang: Inconsistent heuristics in theory and practice. Artif. Intell. 175(9-10): 1570-1603 (2011)

Also see:
https://felner.wixsite.com/home/copy-of-publications-2

DATA SCIENCE FOR SOCIAL GOOD
DATA4GOOD

Dr. Michael Fire, Dr. Galit Fuhrmann Alpert, Aviad Elyashar, Nadav Shalit, Dima Kagan
mickyfi@bgu.ac.il, http://data4good.io

Department of Software and Information Systems Engineering

Expertise
Artificial intelligence

Objectives
The name of our laboratory is the Data Science for Social Good Lab, which reflects our goal—to improve the world through data. In today's world, a gigantic volume of data is now available, and much can be accomplished if we can attain and utilize it in an effective manner. Currently, our lab is working on a variety of cross domain projects. We aim to make our research reproducible and open to all.

Special focus of recent research is the multi-agent path finding problem, which can be expressed as a single-agent search problem, and other settings. Recently, together with colleagues, we have started in a new research project that tries to understand the nature of bidirectional search.

Description
In the field of Security and Privacy, we develop novel algorithms to detect fake profiles (socialbots). We also study privacy and security issues on online platforms, such as online social networks and video conference applications.

In the field of Transportation, we analyze large-scale datasets, such as the smart card (Rav-Kav) dataset, to develop machine-learning-based algorithms for improving public transportation.

In the field of Epidemiology, the COVID-19 outbreak has emphasized the insufficient knowledge available on emerging coronaviruses. By analyzing over 35 million papers from the last 20 years, we explore how previous coronavirus outbreaks and other emerging viral epidemics have been studied over the last two decades.

In the field of Gender Studies, we utilize large-scale datasets to study the gender gap. For example, we fused data from the online movie database, IMDb, with a dataset of movie dialogue subtitles to create the largest available corpus of movie social networks (15,540 networks). Analyzing this data, we investigated gender bias towards female screen characters over the past century.

DATA FOR GOOD LAB

RELEVANT PUBLICATIONS

Dima Kagan, Thomas Chesney, and **Michael Fire,** "Using data science to understand the film industry's gender gap", Nature Humanities and Social Sciences Communications, 2020

Dima Kagan, Jacob Moran-Gilad, and **Michael Fire**, "Scientometric Trends for Coronaviruses and Other Emerging Viral Infections", 2020.

Nadav Shalit, **Michael Fire**, and Eran Ben Elia, "Imputing Missing Boarding Stations With Machine Learning Methods," 2020.

Dima Kagan, **Galit Fuhrmann Alpert**, and **Michael Fire**, "Zooming into Video Conferencing Privacy and Security Threats", 2020.

Michael Fire and Carlos Guestrin, "Over-Optimization of Academic Publishing Metrics: Observing Goodhart's Law in Action", GigaScience, 2019.

Dima Kagan, Galit Fuhrmann Alpert, and **Michael Fire** "Zooming Into Video Conferencing Privacy and Security Threats", 2020

Nadav Shalit, Michael Fire, and Eran Ben Elia, "Imputing Missing Boarding Stations With Machine Learning Methods," 21st International Conference on Intelligent. Data Engineering and Automated Learning (IDEAL), 2020

Dima Kagan, Jacob Moran-Gilad, and **Michael Fire** "Scientometric Trends for Coronaviruses and Other Emerging Viral Infections", GigaScience, 2020

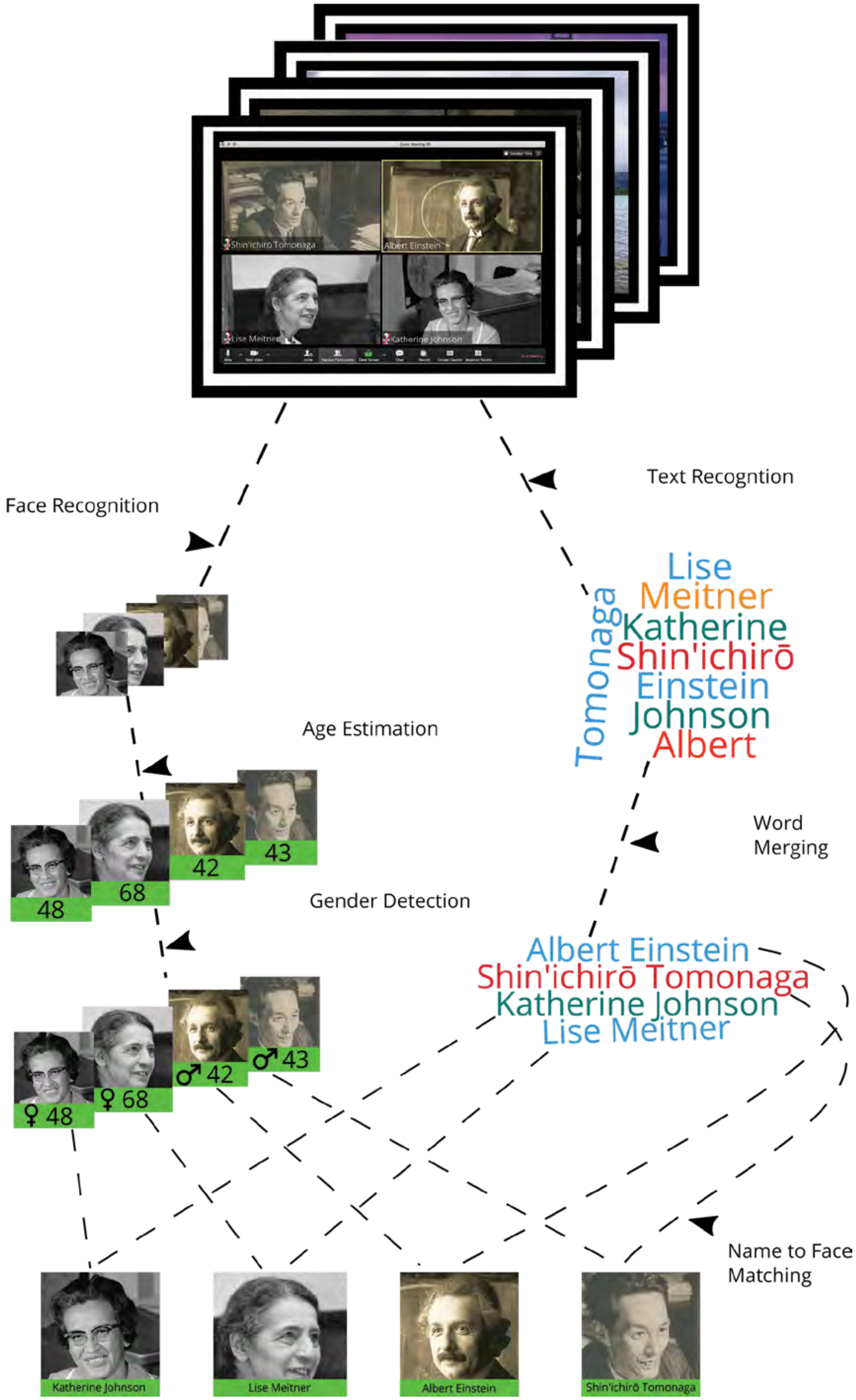
Doron Laadan, Eyal Arviv, and **Michael Fire.** "Using Data Mining for Infrastructure and Safety Violations Discovery in Cities," 2020

Michael Fire and Carlos Guestrin, " The Rise and Fall of Network Stars: Analyzing 2.5 Million Graphs to Reveal How High-Degree Vertices Emerge over Time," Elsevier Information Processing and Management, 2019

Aviad Elyashar, Rami Puzis, and **Michael Fire.** "How Does That Sound? Multi-Language SpokenName2Vec Algorithm Using Speech Generation and Deep Learning, 2020

Michael Fire and Carlos Guestrin, "Over-Optimization of Academic Publishing Metrics: Observing Goodhart's Law in Action", GigaScience, 2019.

Dima Kagan, Yuval Elovici, and **Michael Fire,** "Generic Anomalous Vertices Detection Utilizing Link Prediction Algorithm," Springer Journal of Social Network Analysis and Mining (SNAM), 2018



Data Extraction Process for Studying Video Conferencing Privacy and Security Threats

COMPUTER VISION AND MACHINE LEARNING

Dr. Oren Freifeld, Senior Lecturer
orenfr@cs.bgu.ac.il, https://www.cs.bgu.ac.il/~orenfr/

Department of Computer Science

Expertise
Computer vision, machine learning

Objectives
My current focus is on Bayesian nonparametric methods and on geometric transformations in deep learning, with particular interest in problems such as: unsupervised or semi-supervised learning; video and motion analysis; statistical image models; image or signal alignment; and multiple-camera or multiple-sensor settings.

Description
Computer vision: Statistical models; spatial transformations; geometry in deep learning; motion and tracking; segmentation; registration.

Machine learning: Estimation; Bayesian methods; geometry in machine learning; unsupervised learning; clustering; data fusion; large-scale inference; parallel and distributed computing for inference.

Applications & Products
Motion analysis; video-based multiple-object tracking; image segmentation; change detection; object classification; 3D pose and shape estimation; learning from multiple datasets; missing data; large-scale statistical inference; large-scale deep learning; deep learning in the presence of limited/noisy supervision; hierarchical modeling; medical image analysis; analysis of aerial/satellite imagery.

RELEVANT PUBLICATIONS

Dinari and **Freifeld**. Scalable and Flexible Clustering of Grouped Data via Parallel and Distributed Sampling in Versatile Hierarchical Dirichlet Processes. UAI 2020.

Chelly, Winter, Livak, Rosen, and **Freifeld**. JA-POLS: a Moving-camera Background Model via Joint Alignment and Partially-overlapping Local Subspaces. CVPR 2020.

Shapira-Weber, Eyal, Skafte-Detlefsen, Shriki, and **Freifeld**. Diffeomorphic Temporal Alignment Nets. NeurIPS 2019.

Uziel, Ronen, and **Freifeld**. Bayesian Adaptive Superpixel Segmentation. ICCV 2019.

Skafte-Detlefsen, **Freifeld**, and Hauberg. Deep Diffeomorphic Transformer Networks. CVPR 2018.

DEEP LEARNING FOR IMPROVING IMAGE AND VIDEO COMPRESSION/ANALYSIS

Prof. Ofer Hadar
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Department of Electrical and Computer Engineering

Expertise
Multimedia processing algorithms

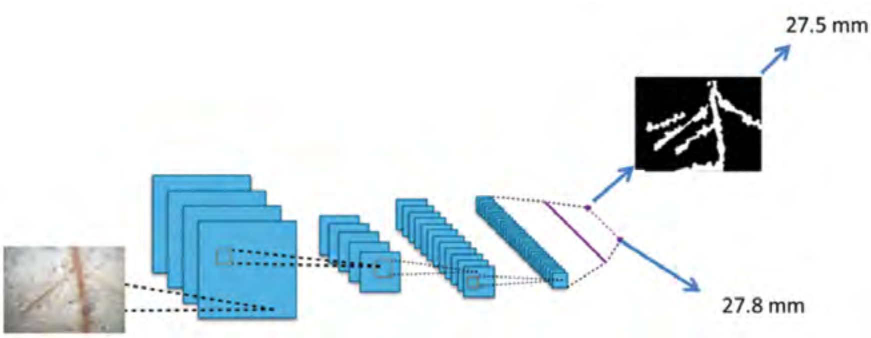
Objectives
Using Neural Networks to improve algorithms and applications for:
- Video compression algorithms
- Remote rehabilitation of physiotherapeutic patients
- Classification of plant root lengths from images for agriculture

Description
1. Neural Networks are used to improve Intra-prediction and Inter-prediction, fundamental algorithms of video compression, that take advantage of redundancies of neighboring pixel values in individual video frames and consecutive temporal frames, respectively. The networks are used to improve these predictions and thus reduce necessary video transmission bandwidth needed for a given quality.

2. Neural Networks are used to study human body movements that are used by physiotherapists as a dictionary for guiding patients remotely to perform the correct exercises, while also providing invaluable focused meta-data feedback to the remote physiotherapist on patients' performance and progress.

3. Convolutional Neural Networks are used to classify images of plant roots and to estimate root length for decision-making purposes in agriculture, such as irrigation management.

Applications & Products
- Improved video compression standards
- Facilitation of remote physiotherapeutic medication



Automatic root-length calculation with Deep Learning

RELEVANT PUBLICATIONS

R. Birman, Y. Segal, and **O. Hadar,** 2020. "Overview of Research in the field of Video Compression using Deep Neural Networks". in Multimedia Tools and Applications, pp.1-24, (2020).

R. Birman, Y. Segal, **O. Hadar**, and J. Benois-Pineau, "Improvements of Motion Estimation and Coding using Neural Networks", arXiv:2002.10439, (2020).

R. Birman, Y. Segal, A. D. Malka, **O. Hadar**, "Intra prediction with deep learning", in SPIE Optics + Photonics conference, San Diego, California (USA), (2018).

ANOMALY DETECTION AND DIAGNOSIS

Prof. Meir Kalech
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AiDnd Lab: http://aidnd.ise.bgu.ac.il/

Department of Software and Information Systems Engineering

Expertise
Anomaly detection and diagnosis

Objectives
Modern mechanical systems are saturated with sensors. Faults that occur due to false sensing or runtime errors and hardware failures need to be detected quickly and the root cause of the failure must be diagnosed. This presents significant challenges: (1) to quickly detect the fault with high precision; (2) to identify the root cause of the failure (diagnosis); and (3) to support a decision that is derived from the implications of the fault.

Description
The AiDnD laboratory, addresses these challenges by combining two AI approaches for fault detection and diagnosis.
(1) Model-based diagnosis: the different layers of the system are modeled, including the low level of the components, actuators, and sensors, and the higher levels, as abstracted in the onboard system computer. In addition, the connections between the layers are modeled. Based on these models, we describe fault detection and diagnostic techniques. (2) Data-driven: we learn the dependencies between sensors online, after which we use the dependencies and a structural model of the system to diagnose faults. We propose to combine these two approaches by tracking both the higher-level abstractions and the sensor readings. Together, we increase the fault detection and diagnostic accuracy of the system. Furthermore, the models we employ may provide knowledge of the fault's implications, which can be used to give a useful warning.

Applications & Products
- Anomaly detection methods, devices and systems
- Sensor fault detection and diagnosis for autonomous systems

RELEVANT PUBLICATIONS

Eliahu Khalastchi, **Meir Kalech**: A sensor-based approach for fault detection and diagnosis for robotic systems. Auton. *Robots* 42(6): 1231-1248 (2018).

Eliahu Khalastchi, **Meir Kalech**: On Fault Detection and Diagnosis in Robotic Systems. ACM Comput. Surv. 51(1): 9:1-9:24 (2018)

Eliahu Khalastchi, **Meir Kalech**, Lior Rokach: A hybrid approach for improving unsupervised fault detection for robotic systems. *Expert Syst. Appl.* 81: 372-383 (2017).

Eliahu Khalastchi, **Meir Kalech**, Gal A. Kaminka, Raz Lin: Online data-driven anomaly detection in autonomous robots. *Knowl. Inf. Syst.* 43(3): 657-688 (2015).

Eliahu Khalastchi, **Meir Kalech**, Lior Rokach: A hybrid approach for fault detection in autonomous physical agents. AAMAS 2014: 941-948, 2013

Eliahu Khalastchi, **Meir Kalech**, Lior Rokach: Sensor fault detection and diagnosis for autonomous systems. *AAMAS* 2013: 15-22, 2011.

MULTI-OBJECTIVE TASK SCHEDULING AND RESOURCE OPTIMIZATION USING DEEP REINFORCEMENT LEARNING

Dr. Gilad Katz and **Prof. Asaf Shabtai**
giladkz@bgu.ac.il

Department of Software and Information Systems Engineering

Expertise
Deep learning, deep reinforcement learning, recommender systems, NLP

Objectives
Multi-objective task scheduling (MOTS) is task scheduling while optimizing multiple and, possibly, contradictory constraints. A challenging extension of this problem occurs when every individual task is a multi-objective optimization problem by itself. The application of DRL to MOTS has been stymied by two challenges: a) the inability of the DRL algorithm to ensure that every item is processed identically regardless of its position in the queue; b) the need to manage large queues, which results in large neural architectures and long training times.

Description
We present MERLIN—a robust, hierarchical and near-optimal DRL-based approach for multi-objective task scheduling. MERLIN creates one neural network for the processing of individual tasks and another for the scheduling of the overall queue. Our approach creates optimal solutions at the individual item level, then schedules the queue to maximize utility. MERLIN produces smaller networks, shorter training times, and ensures that an item is processed in the same manner regardless of its position in the queue. We also present a novel approach for efficiently applying DRL-based solutions on very large queues, and demonstrate how we effectively scale MERLIN to process queues that are larger by orders of magnitude than those on which it was trained.

Applications & Products
MERLIN is applicable to any queue scheduling domain where the processing of each item is a problem in itself. Examples include: Malware detection (our evaluated domain, 22% improvement over leading benchmarks), Medical tests (e.g., COVID-19 testing), maintenance and manufacturing queues, traffic light management.

RELEVANT PUBLICATIONS

Heffetz, Yuval, Roman Vainstein, **Gilad Katz**, and Lior Rokach. "DeepLine: AutoML Tool for Pipelines Generation using Deep Reinforcement Learning and Hierarchical Actions Filtering." in KDD 2020.

Birman, Yoni, Shaked Hindi, **Gilad Katz** and **Asaf Shabtai**. “Cost-effective malware detection as a service over serverless cloud using deep reinforcement learning.” In 2020 20th IEEE/ACM International Symposium on Cluster, Cloud and Internet Computing (CCGRID), 2020.

Zaks, Guy, and **Gilad Katz**. "CoMet: A Meta Learning-Based Approach for Cross-Dataset Labeling Using Co-Training." In Proceedings of the 19th International Conference on Autonomous Agents and Multi Agent Systems (AAMAS), 2020.

Cohen-Shapira, Noy, Lior Rokach, Bracha Shapira, **Gilad Katz** and Romain Vainshtein. “AutoGRD: Model Recommendation Through Graphical Dataset Representation.” Conference on Information and Knowledge Management (CIKM). ACM, 2019.

METRIC SPACES AND MARKOV CHAINS

Prof. Aryeh Kontorovich
karyeh@cs.bgu.ac.il

Department of Computer Science

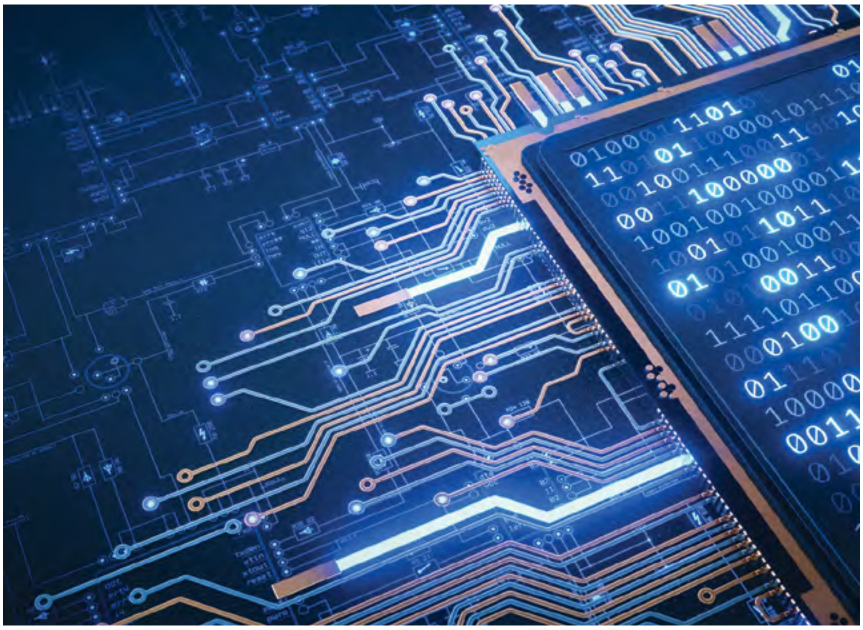
Expertise
Machine learning

Objectives
My main area of research is theoretical machine learning: probability, statistics, Markov chains, metric spaces.

A specific Robotics application includes:
A. Biess, A. Kontorovich, Y. Makarychev, H. Zaichyk. Regression via Kirszbraun Extension, https://arxiv.org/abs/1905.11930

Description
Aryeh Kontorovich received his undergraduate degree in mathematics with a certificate in applied mathematics from Princeton University in 2001. His M.Sc. and Ph.D. are from Carnegie Mellon University, where he graduated in 2007. After a postdoctoral fellowship at the Weizmann Institute of Science, he joined the Department of Computer Science at Ben-Gurion University of the Negev in 2009, where he is currently an associate professor. His research interests are mainly in machine learning, with a focus on probability, statistics, Markov chains, and metric spaces.

Applications & Products
See https://tinyurl.com/kontorovich-projects-code



RELEVANT PUBLICATIONS

G. Wolfer, **A. Kontorovich**. Estimating the Mixing Time of Ergodic Markov Chains. *COLT* 2019.

D. Hsu, **A. Kontorovich**, D. Levin, Y. Peres, C. Szepesvári, G. Wolfer. Mixing Time Estimation in Reversible Markov Chains from a Single Sample Path. Annals of Applied Probability, 2019.
G. Wolfer, **A. Kontorovich**. Minimax Learning of Ergodic Markov Chains. *ALT* 2019.

A. Kontorovich, I. Pinelis. Exact Lower Bounds for the Agnostic Probably-Approximately-Correct (PAC) Machine Learning Model. *Annals of Statistics*, 2019.
L. Gottlieb, **A. Kontorovich**, P. Nisnevitch. Near-optimal sample compression for nearest neighbors. *IEEE Transactions on Information Theory*, 2018.

A. Kontorovich, S. Sabato, R. Urner. Active Nearest-Neighbor Learning in Metric Spaces. *Journal of Machine Learning Research*, 2017.

L. Gottlieb, **A. Kontorovich**, R. Krauthgamer. Efficient Regression in Metric Spaces via Approximate Lipschitz Extension. *IEEE Transactions on Information Theory*, 2017.

L. Gottlieb, **A. Kontorovich**, R. Krauthgamer. Adaptive Metric Dimensionality Reduction. Invited to Theoretical Computer Science, 2016.

D. Berend, **A. Kontorovich**. A finite sample analysis of the Naive Bayes classifier, *Journal of Machine Learning Research*, 2015.

L. Gottlieb, **A. Kontorovich**, R. Krauthgamer. Efficient classification for metric data. *IEEE Transactions on Information Theory*, 2014.

D. Berend, P. Harremoës, **A. Kontorovich**. Minimum KL-divergence on complements of L_1 balls. *IEEE Transactions on Information Theory*, 2014.

D. Angluin, J. Aspnes, S. Eisenstat, **A. Kontorovich**. On the Learnability of Shuffle Ideals. *Journal of Machine Learning Research*, 2013.

CROSS-LINGUAL TEXT MINING

Prof. Mark Last
Director, Data and Text Mining Laboratory
mlast@bgu.ac.il

Department of Software and Information Systems Engineering

Expertise
Data stream mining, cross-lingual text mining, video understanding, cyber intelligence and security, medical informatics

Objectives
At the Data and Text Mining Lab, we have developed novel methods for mining real-world data in such diverse domains as digital health care, precision agriculture, intelligent transportation, smart energy grid, predictive seismology, cyber security and many others. Part of our research is directed towards privacy-preserving algorithms for publishing and mining sensitive data.
We have also introduced an AI-based language-independent approach for automated text summarization. With the huge increase of online textual data in multiple languages, there is a need for automated tools for extracting salient information from text files, such as articles, posts or interviews. Most available solutions are language dependent and require training the algorithms on large amounts of manually annotated texts in a target language. In our recent work on natural language understanding, we have focused on identifying conceptual metaphors in multi-lingual text corpora, automated question generation, and detection of deceptive content on social media platforms.

Description
In our research, we have introduced a language-independent tool for summarizing text. The novel AI technology is based on an evolutionary algorithm that ranks document sentences, using statistical sentence features, which can be calculated for sentences in any language, and then extracts top–ranking sentences into a summary. The method called MUSE – Multilingual Sentence Extractor – was tested on nine languages: English, Hebrew, Arabic, Persian, Russian, Chinese, German, French, and Spanish. Its summarization quality was evaluated on four languages: English, Hebrew, Arabic, and Persian and showed a high level of similarity to human-generated summaries. Our experimental results reveal that MUSE can be effectively applied across several languages without retraining it on a summarized corpus in each new language.

Applications & Products
MUSE – Multilingual Sentence Extractor, which selects a subset of the most relevant sentences from a source document in any language, is invaluable for being able to quickly summarize large quantities of multilingual text. This ability is crucial for search engines and business intelligence platforms as well as for end-users such as students, researchers, intelligence experts, and media analysts.

RELEVANT PUBLICATIONS

M. Bakshi and **M. Last** (2020). CryptoRNN-Privacy-Preserving Recurrent Neural Networks Using Homomorphic Encryption. In International Symposium on Cyber Security Cryptography and Machine Learning. Springer, Cham, pp. 245-253.

M. Last and G. Danon (2020). "Automatic Question Generation", WIREs Data Mining and Knowledge Discovery. https://doi.org/10.1002/widm.1382

N. Vanetik, M. Litvak, **M. Last**, and E. Churkin (2020). “An Unsupervised Constrained Optimization Approach to Compressive Summarization”, Information Sciences, Vol. 509, pp. 22-35.

R. Chongtay, **M. Last** and B. Berendt (2018). “Responsive News Summarization for Ubiquitous Consumption on Multiple Mobile Devices”. In 23rd International Conference on Intelligent User Interfaces (IUI '18). ACM, New York, NY, USA, pp. 433-437.

M. Litvak, N. Vanetik, **M. Last**, and E. Churkin (2016). "MUSEEC: A Multilingual Text Summarization Tool". In Proceedings of the 54th Annual Meeting of the Association for Computational Linguistics (ACL 2016)—System Demonstrations, pp. 73–78, Berlin, Germany, August 7-12, 2016.

M. Litvak, N. Vanetik, & **M. Last** (2015). “Krimping Texts for Better Summarization”. In Proceedings of the 2015 Conference on Empirical Methods in Natural Language Processing (EMNLP 2015), pp.1931–1935, Lisbon, Portugal, 17-21 September 2015.

Y. Neuman, D. Assaf, Y. Cohen, **M. Last**, Sh. Argamon, N. Howard, O. Frieder (2013). "Metaphor Identification in Large Texts Corpora", PLoS ONE 8(4): e62343. doi:10.1371/journal.pone.0062343.

M. Litvak and **M. Last** (2013). “Cross-lingual training of summarization systems using annotated corpora in a foreign language” Information Retrieval, Volume 16, Issue 5, pp 629-656.

L. Gandy, N. Allan, M. Atallah, O. Frieder, N. Howard, S. Kanareykin, M. Koppel, **M. Last**, Y. Neuman and Sh. Argamon (2013). "Automatic Identification of Conceptual Metaphors with Limited Knowledge", in Proceedings of the Twenty-Seventh AAAI Conference on Artificial Intelligence (AAAI-13), Bellevue, Washington, USA, July 14-18, 2013, pp. 328-334.

M. Litvak, **M. Last**, and M. Friedman (2010). “A new Approach to Improving Multilingual Summarization using a Genetic Algorithm”, in Proceedings of the 48th Annual Meeting of the Association for Computational Linguistics (ACL 2010), Uppsala, Sweden, July 11–16, 2010, pp. 927–936.

THE DATA SCIENCE RESEARCH CENTER

https://in.bgu.ac.il/en/data-science/Pages/default.aspx

Steering committee members
Prof. Mark Last
Prof. Aryeh Kontorovich, Prof. Boaz Lerner, Prof. Haim Permuter, Prof. Bracha Shapira

Data Science is a multidisciplinary field aimed at extracting novel and potentially useful knowledge from real-world data. The Data Science Research Center at Ben-Gurion University of the Negev (DSRC@BGU), founded by Prof. Mark Last in April 2018, has brought together one of the largest multidisciplinary groups of data scientists in Israel. The Center currently includes about 100 faculty members from 20 different departments in all BGU Faculties (Engineering Sciences, Natural Sciences, Humanities and Social Sciences, Health Sciences, and the Blaustein Institutes for Desert Studies), as well as from the Soroka University Medical Center.

Objectives

- To advance the state-of-the-art in the core fields of data science;
- To encourage collaboration between data scientists and researchers from other relevant fields (health care, biology, robotics, cyber security, economics, earth sciences, social sciences, digital humanities, etc.);
- To educate new generations of data-aware professionals.

Applications & Products

Selected projects funded by the Center in 2020:

- Emotionally Inspired Analytics of Video Content
- Multimodal Machine Learning for Drug Knowledge Discovery
- Nearest neighbor sample compression at large scales: The case of Android malware classification
- Restructuring Search in Code Repositories
- Applications of Learning in Big Combinatorial Optimization Problems
- Corona diagnosis using audio processing methods
- G-quadruplex structure prediction in the SARS-CoV-2 genome to identify potential novel therapeutic targets for COVID-19

DSRC@BGU
DATA SCIENCE RESEARCH CENTER
BEN-GURION UNIVERSITY OF THE NEGEV


NORTH KOREA
SOUTH KOREA

MACHINE LEARNING FOR PRECISION MEDICINE

Prof. Boaz Lerner
boaz@bgu.ac.il, http://www.ee.bgu.ac.il/~boaz/

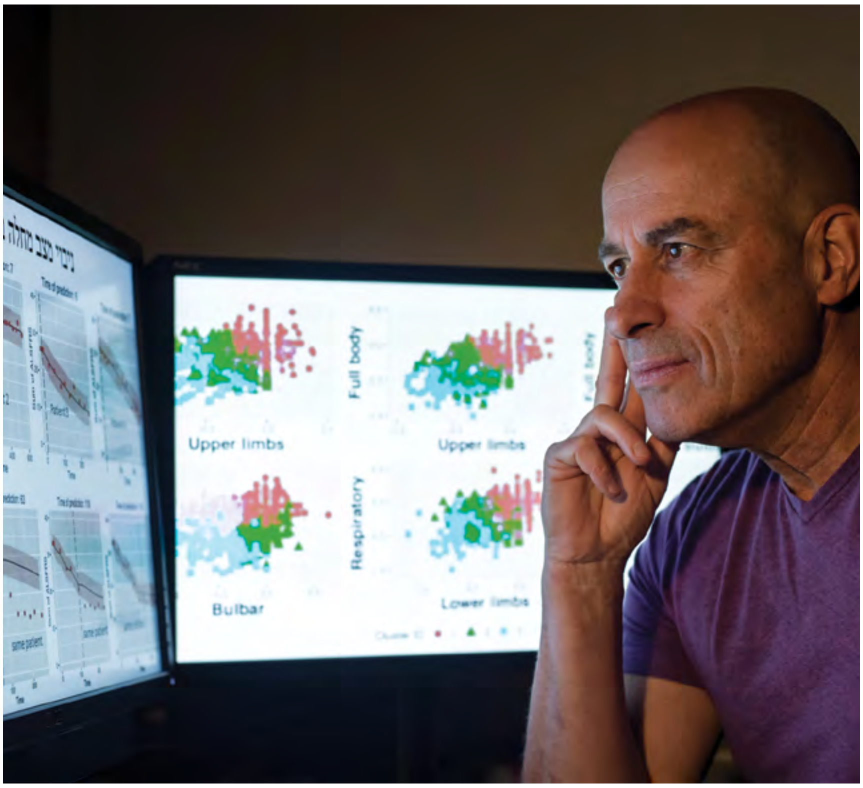
Department of Industrial Engineering & Management

Expertise
Machine learning, graphical models, precision medicine

Objectives
My research lies in machine learning and, specifically, in learning graphical models (Bayesian networks), latent variable models, and temporal models, in the interpretation and visualization of deep neural networks, and in the application of machine learning to health, agriculture, and other domains.

Description
- Graphical models: learning Bayesian network structure, learning latent variable models, learning temporal models
- Deep learning: interpretation and visualization
- Learning mobility patterns
- Machine learning for precision medicine and precision agriculture

Applications & Products
Precision medicine; precision agriculture; road safety.



RELEVANT PUBLICATIONS

Halbersberg, D., Wienreb, M., and **Lerner, B.** (2020). Joint maximization of accuracy and information for learning the structure of a Bayesian network classifier," Machine Learning, 109, 1039-1099.

Konforti, Y., Shpigler, A., **Lerner, B.**, and Bar Hillel, A. (2020). Inference graphs for CNN interpretation, 16th European Conference on Computer Vision (ECCV).

Halbersberg, D. and **Lerner, B.** (2020). "Local to global learning of a latent dynamic Bayesian network", 24th European Conference on Artificial Intelligence (ECAI 2020), Santiago de Compostela, Spain.

Asbeh, N., and **Lerner, B**. (2016). "Learning latent variable models by pairwise cluster comparison. Part II – Algorithm and evaluation." *Journal of Machine Learning Research 17* (233), 1-45.

Asbeh, N., and **Lerner, B**. (2016). "Learning latent variable models by pairwise cluster comparison. Part I – Theory and overview." *Journal of Machine Learning Research* 17 (224), 1-52.

Kelner, R. and **Lerner, B**. (2012) "Learning Bayesian network classifiers by risk minimization." *International Journal of Approximate Reasoning,* vol. 53, 248-272.

Yehezkel, R. and **Lerner, B**. (2009). "Bayesian network structure learning by recursive autonomy identification." *Journal of Machine Learning Research,* 10, 1527-1570.

Vigdor, B. and **Lerner, B**. (2007). "The Bayesian ARTMAP." *IEEE Transactions on Neural Networks,* 18, 1628-1644.

DEEP LEARNING FOR IMPROVED PERCEPTION

Dr. Omer Lev
omerlev@bgu.ac.il

Department of Industrial Engineering & Management

Expertise
Decision making, multi-agent systems

Objectives
To understand various phenomena involving the interaction of a large group of agents (human, artificial, or both). This involves a game-theoretical analysis, while keeping the research closely related to real-world data and observable behavior. In particular, the focus is on decision-making processes and crowd-activities: crowdsourcing, crowdfunding, networks, and mechanism design.

Description
To understand multi-agent activities, they need to be modelled well, and then an understanding of what is possible – or impossible – to do in these activities can be expanded. In some cases, building a model and exploring it is straightforward. However, in others – particularly involving novel activities, such as crowdfunding – the research is more exploratory, and tries to understand these phenomena from real-world data.

Applications & Products
Designing environments to encourage particular behaviors from users. Increasing user interaction in crowd-based activities.

RELEVANT PUBLICATIONS

Please see:
http://www.bgu.ac.il/~omerlev/?papers

Examples:
One Size Does Not Fit All: Badge Behavior in Q&A sites – *UMAP 2019*

Primarily About Primaries – *AAAI 2019*
Seasonal Goods and Spoiled Milk:

Pricing for a Limited Shelf-Life – *AAMAS 2018*

Group Recommendations: Axioms, Impossibilities, and Random Walks – *TARK 2017*

SOCIAL ROBOTS FOR REHABILITATION

Dr. Shelly Levy-Tzedek
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Department of Physical Therapy

Expertise
Social robots for rehabilitation

Objectives
A closed-loop robotic platform for post-stroke rehabilitation.

Description
We are developing a novel gamified system for post-stroke long-term rehabilitation, using the humanoid robot, Pepper (SoftBank, Aldebaran). We employ a participatory-design approach, incorporating into our system design insights from both expert clinicians and from stroke patients who underwent long-term intervention with the robot. Both the clinicians and the patients found the robot and the gamified system we developed to be engaging, motivating, and meeting the needs of upper limb rehabilitation. In parallel, we developed a machine-learning algorithm for the automatic detection of undesirable movements, to enable continuous safe practice at home and in the clinic. We aim to create a fully autonomous system, to be used by patients and clinics worldwide.

Applications & Products
A robotic platform to be used in clinics and at home for post-stroke rehabilitation.

RELEVANT PUBLICATIONS

Kashi S., Feingold Polak R., Lerner B., Rokach L., & **Levy- Tzedek S.** (2020) A Machine- Learning Model for Automatic Detection of Movement Compensations in Stroke Patients. IEEE Transactions on Emerging Topics in Computing (in press)

Feingold Polak R., & **Levy- Tzedek S.** (2020) Social Robot for rehabilitation: Expert clinicians and post-stroke patients' evaluation following long-term intervention. Human- Robot Interaction

Feingold Polak R., Elishay A., Shahar Y., Stein M., Edan Y., **Levy-Tzedek S.** (2018) Differences between young and old users when interacting with a humanoid robot: a qualitative usability study. Paladyn, *Journal of Behavioral Robotics* 9(1): 183-192

CYBER SECURITY

Prof. Oded Margalit
odedm@post.bgu.ac.il

Department of Computer Science

Expertise
Cyber security, AI, machine learning & data science, theory of computer science

Objectives
As an adjunct professor at BGU, the CTO of Citi's Security Innovation Center (SIC), and other volunteering activities, like serving as a member of a steering committee for cyber education for youth - I'm combining the three worlds of academic research & teaching; Industrial needs; and youth education.

I'm looking for ways to close the minorities and gender inequality in computer science education.

Description
I love riddles, and computer science education in general and cyber in particular. Therefore I'm running several relevant events, like CodeGuru (computer science for K9-12); IEEEXtreme (programming for students); Capture The Flags (CTFs) like CSCML; and more.

RELEVANT PUBLICATIONS

"Keystroke dynamics obfuscation using key grouping" (Expert Syst. Appl. 143 (2020))

"Decompiled APK based malicious code classification" (Future Gener. Comput. Syst. 110: 135-147 (2020))

MOVEMENT ANALYSIS & REHABILITATION LABORATORY

Prof. Itshak Melzer
Director, Recanati School for Community Health Professions
Director, Schwartz Movement Analysis & Rehabilitation Laboratory
itzikm@bgu.ac.il

Department of Physical Therapy

Expertise
Balance control, falls, elderly, AI, robotic for older adults

Objectives
- Developing a novel Dynamic Gait Recovery Index (DGRI) to identify fallers based on recovery postural reactions during walking.
- Exploring whether these recovery "reflex-like responses" can be improved by intervention.
- Exploring what is the best regime to improve these responses (block training vs. random training) to better understand the locomotor adaptation and motor learning that are important for rehabilitation and treatment.
- Exploring which are the areas in the brain that are associated with balance recovery, using MRI, fMRI, and CT.

Description
Prof. Melzer has found that balance perturbation training can improve balance reactive responses in older adults, as well as during the early sub-acute phase of stroke, which may influence fall risk. In addition, the effects of lesion characteristics (location and extent) on balance control were explored in stroke patients using voxel-based lesion-symptom brain MRI and CT mapping. It was found that damage to the corticospinal tract, in its passage in the corona radiata and in the posterior limb of the internal capsule, and damage to the putamen and the external capsule, are associated with impaired balance recovery and gait function.

Applications & Products
- BaMPer System - BALANCE PERTURBATION SYSTEM AND TRAINER (PCT/IB2010/052079)
- PerStBiRo system - A BICYCLE-SIMULATOR BALANCE TRAINER (Provisional Patent Application No. 62/993,820)

TEMPORAL DATA ANALYTICS

Dr. Robert Moskovitch
Head, Complex Data Analytics Laboratory
cdalab.ise.bgu.ac.il

Department of Software and Information Systems Engineering

Expertise
Distributed and multi agent models and problem solving

Description
The Complex Data Analytics Lab (CDALab), headed by Dr. Moskovitch, does research in the field of data science (AI, Data Mining, and Machine Learning), in general, while focusing, specifically, on Temporal Data Analysis. The lab develops novel methods for the analysis of heterogeneous multivariate longitudinal data, including the development of fast temporal pattern discovery algorithms. It also focuses on the use of the temporal patterns for classification, and the discovery of predictive patterns, as well as learning prediction models.

The lab focuses mainly on longitudinal data, including in domains such as Telecom, healthcare, cyber security, and more. The lab is funded by projects with industry, such as IBM. A recent project, funded by Amdocs' data science group, is predicting call center interactions based on usage data. Additional collaborations include collaboration on complications prediction in Intensive Care Units with the largest medical center in New Delhi, a hospital in Taiwan, Mount Sinai Hospital in New York, and Assuta in Israel. For the past ten years, the lab has collaborated with Maccabi Healthcare Services on preventable mortality prediction in diabetic patients' data, using Maccabi's Electronic Health Records dataset.
A recently funded project, in collaboration with Maccabi and Assuta Medical Center, is on Sleep Apnea. In the field of cyber security, the lab works on anomaly detection in computer networks.

RELEVANT PUBLICATIONS

Robert Moskovitch, Fernanda Polubriaginof, Aviram Weiss, Patrick Ryan, Nicholas Tatonetti, Procedure Events Prediction via Time Intervals Analytics, *Journal of Biomedical Informatics*, 2017.

Robert Moskovitch, Yuval Shahar, Classification Driven Temporal Discretization of Multivariate Time Series, *Data Mining and Knowledge Discovery*, 29, 4, 871-913, 2015.

Robert Moskovitch, Fei Wang, Colin Walsh, George Hripcsak, Nicholas Tatonetti, Prediction of Outcome Events via Time Intervals Mining, *IEEE International Conference on Data Mining (ICDM)*, Atlantic City, USA, 2015.

RELEVANT PUBLICATIONS

A. Shusterman, Z. Avraham, E. Croitoru, Y. Haskal, L. Kang, D. Levi, Y. Meltser, P. Mittal, **Y. Oren,** and Y. Yarom, *Website Fingerprinting Through the Cache Occupancy Channel and its Real World Practicality,* IEEE Transactions on Dependable and Secure Computing, 2020.

I. Fayans, Y. Motro, L. Rokach, **Y. Oren,** and J. Moran-Gilad, *Cyber Security Threats in the Microbial Genomics Era: Implications to Public Health,* Eurosurveillance, 2020.

K. S. Tharayil, B. Farshteindiker, S. Eyal, N. Hasidim, R. Hershkovitz, S. Houri, I. Yoffe (Iofedov), M. Oren, and **Y. Oren,** *Sensor Defense In-Software (SDI): Practical Software Based Detection of Spoofing Attacks on Position Sensors,* Engineering Applications of Artificial Intelligence Volume 95, 2020.

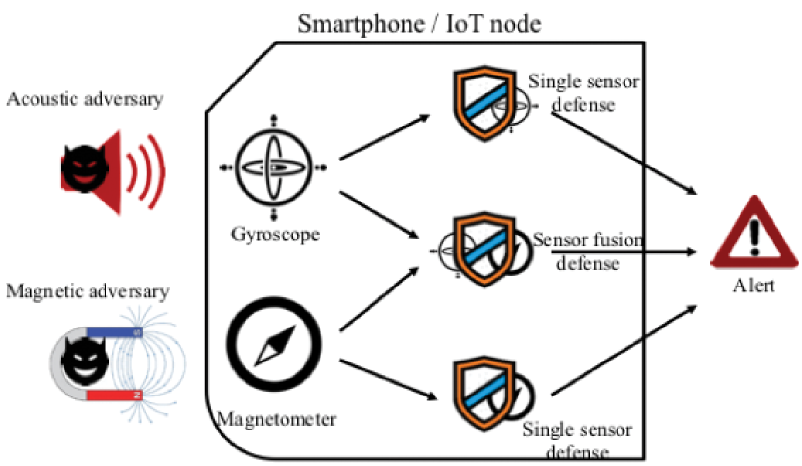
IMPLEMENTATION SECURITY

Dr. Yossi Oren
yos@bgu.ac.il, https://orenlab.sise.bgu.ac.il/p/SDI

Department of Software and Information Systems Engineering

Expertise
Implementation security and side-channel attacks

Description
Position sensors, such as the gyroscope, the magnetometer, and the accelerometer, are found in a staggering variety of devices, from smartphones and UAVs to autonomous robots. Several studies have shown how adversaries can mount spoofing attacks to remotely corrupt or even completely control the outputs of these sensors. With more and more critical applications relying on sensor readings to make important decisions, defending sensors from these attacks is of prime importance. Dr. Oren's group is working on practical software-based defenses against attacks on two common types of position sensors, specifically the gyroscope and the magnetometer.



Sensor Defense in Software

Applications & Products
Increase security of smartphones, UAVs, autonomous robots, and other IoT devices.

DEEP LEARNING IN COMPUTATIONAL BIOLOGY

Dr. Yaron Orenstein
yaronore@bgu.ac.il, http://wwwee.ee.bgu.ac.il/~cb/

Department of Electrical and Computer Engineering

Expertise
Bioinformatics and computational biology

Objective
Our lab develops algorithms to infer predictive models of molecular interactions based on high-throughput biological data.

Description
The recent advancement in neural networks, termed deep learning, has attracted much attention in the field of computational biology.
This most advanced machine learning method is utilized to generate more accurate protein –DNA, –RNA, and –peptide binding models. We apply it successfully to many high-throughput datasets, and we plan to take it even further by incorporating several orthogonal sources to improve in vivo prediction.

We have applied the method successfully to many high-throughput datasets, and we plan to take it even further by incorporating several orthogonal sources to improve in vivo binding prediction.

Applications & Products
All the software developed in the lab are freely available.

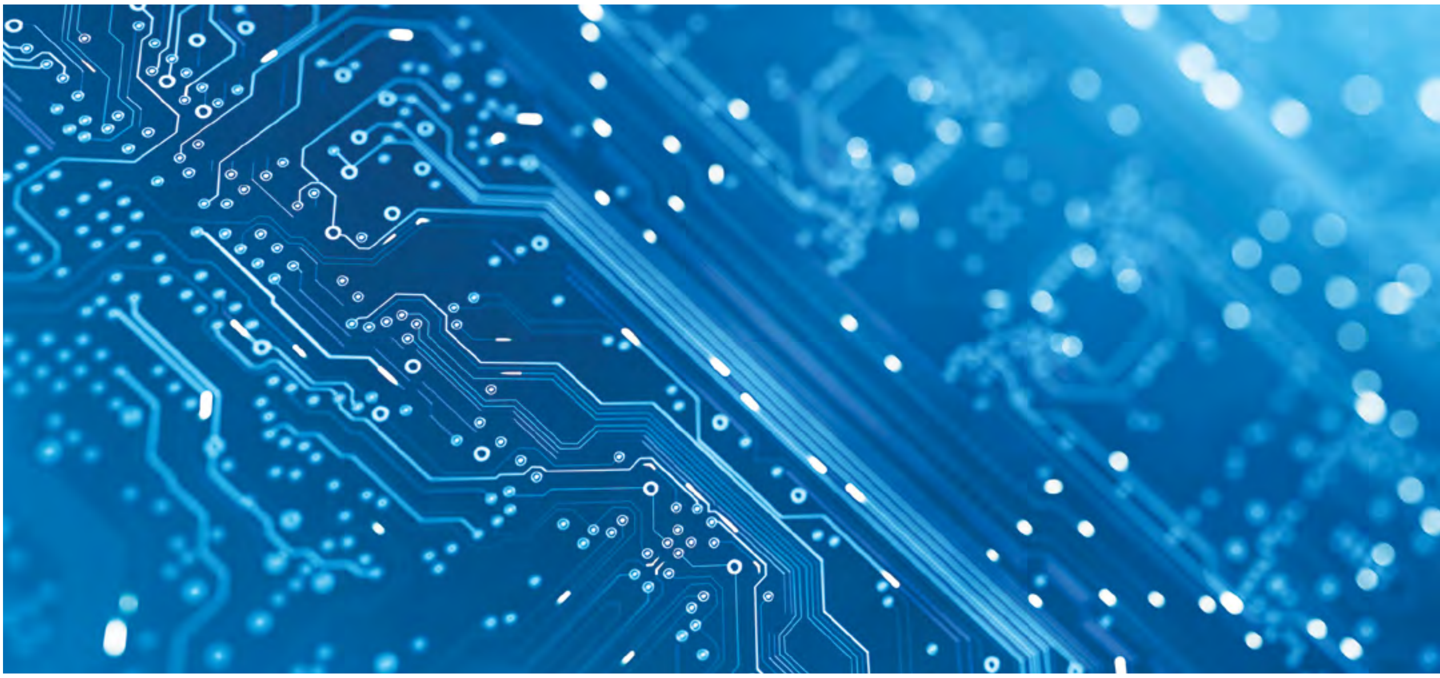
RELEVANT PUBLICATIONS

M. Asif, and **Y. Orenstein**, DeepSELEX: Inferring DNA-binding preferences from HT-SELEX data using multi-class CNNs. Bioinformatics (2020).

M. Barshai, and **Y. Orenstein**, Predicting G-Quadruplexes from DNA Sequences Using Multi-Kernel Convolutional Neural Networks. ACM-BCB (2019).

I. Ben-Bassat, B. Chor, and **Y. Orenstein**, A deep neural network approach for learning intrinsic protein-RNA binding preferences. Bioinformatics (2018).

Also see:
http://wwwee.ee.bgu.ac.il/~yaronore/



NETWORK OPTIMIZATION PROBLEMS

Dr. Rami Puzis
puzis@bgu.ac.il

Department of Software and Information Systems Engineering

Expertise
Search, machine learning, complex networks, cyber security

Description
Optimization problems related to traffic monitoring in computer communication networks: To efficiently deploy monitoring and filtering facilities in a computer communication network, we study the typical structure of an NSP network and identify routers possessing the highest collaborative impact on the communication flows. Heuristic search algorithms were employed to find the locations that have the highest Group Betweenness Centrality and, thus, produce cost-effective deployment of traffic inspection devices.

Computer network hardening through attack graph optimization: Before executing an attack, adversaries usually explore the victim's network in an attempt to infer the network topology and identify vulnerabilities in the victim's servers and personal computers. We use the attack graphs to model the path of an attacker making its way towards a target in a given network. We investigate various combinatorial problems on attack graphs, including (1) Deployment optimization of fake vulnerabilities targeted to slow down the lateral movement of the attacker and increase the amount of noise it generates. (2) Deployment optimization of IOT devices in an organization, while minimizing the additional risk of penetration due to the new IOT devices. (3) Goal-recognition algorithms that identify the end goal of an attacker and the attack path based on partial noisy observations.

Network alignment: Network Alignment (NA) is a generalization of the graph isomorphism problem for non-isomorphic graphs, where the goal is to find node mapping as close as possible to iso-morphism. Recent, successful NA algorithms follow a search-based approach, such as simulated annealing. We speed up search-based NA algorithms by pruning the search-space based on heuristic rules derived from the topological features of the aligned nodes. We further propose multiple new objective functions borrowed from the domain of statistical analysis.

Applications & Products
- Target oriented network intelligence collection (TONIC) for efficient intelligent crawling of social networks.
- eDare(II) – a framework for optimizing the placement of network intrusion detection systems (NIDS) in computer communication networks.

RELEVANT PUBLICATIONS

Rami Puzis, Liron Samama-Kachko, Barak Hagbi, Roni Stern, Ariel Felner, "Target Oriented Network Intelligence Collection: Efficient Exploration of Social Networks" ,World Wide Web Journal, accepted (2018).

Dov Shirtz, **Rami Puzis,** Yuval Elovici, "A Swarm Model for Estimating Reliability and Scheduling System Maintenance", Enterprise Information Systems (2014).

Roni Stern, Ariel Felner, Jur van den Berg, **Rami Puzis,** Rajat Shah, Ken Goldberg, "Potential-Based Bounded-Cost Search and Non-Parametric Anytime A", Artificial Intelligence, 214, 1-25 (2014).

Reuth Mirsky, Ya'ar Shalom, Ahmad Majadly, Ya'akov (Kobi) Gal, **Rami Puzis,** Ariel Felner, "New Goal Recognition Algorithms using Attack Graphs", CSCML (2019).

Roni Stern, Scott Kiesel, **Rami Puzis,** Ariel Felner, Wheeler Ruml, "Max is More than Min: Solving Maximization Problems with Heuristic Search", SoCS 2014, IJCAI 2015 (2014).

BIOMECHANICS AND WEARABLE ROBOTS

Dr. Raziel Riemer
rriemer@bgu.ac.il

Department of Industrial Engineering and Management

Expertise
Biomechanics and robotics focusing on human motion and wearable robots (exoskeletons), ergonomics, sustainability

Objectives
The Biomechanics and Wearable Robots Laboratory aims to advance the science of human motion; develop wearable robots (exoskeletons) and study the interaction between the human user and the exoskeleton; develop new methods for the design of the human working environment based on simulation and optimization algorithms; and develop a decision-making tool for policy makers for reducing the carbon footprint and waste.

Description
- Science of human motion:
  > Motion analysis (motion capture, IMU and sensors)
  > Physiological measurements (metabolic, electromyography, near-infrared spectroscopy)
  > Human locomotion energetics
- Wearable robots:
  > Designing and building a biomechanical energy harvesting device
  > Designing and building an exoskeleton for jumping
  > Simulating human–exoskeleton interactions
- Human working environment:
  > Developing equations for human performance based on experimental data
  > Developing a novel method for workspace design using simulation and optimization algorithms
- Sustainability:
  > Developing a decision-making tool based on nonlinear optimization for policy makers to reduce the carbon footprint and waste.

Applications & Products
My method for workspace design using simulation and optimization algorithms has been integrated by Siemens into its HEEDS software package

RELEVANT PUBLICATIONS

Harari, Y., Bechar, A., and **Riemer, R.** 2019. Simulation-based optimization methodology for human-machine system design that maximizes productivity while considering ergonomic constraints. IEEE Transactions on Human-Machine Systems (THMS). Vol 49, Issue 5, 440-448.

Riemer, R. 2017. Automated simulation – based workplace design that considers ergonomics and productivity. International Journal of Simulation Modelling, Vol. 16, Issue 1, 5-18.

Riemer, R. and Shapiro, A. 2011. Biomechanical energy harvesting from human motion: theory, state of the art, design guidelines, and future directions. Journal of NeuroEngineering and Rehabilitation, Vol. 8, Issue 22, 1-13.
Harari, Y., Bechar, A., Raschke, U., and

BIOMEDICAL IMAGE COMPUTING VIA DEEP LEARNING

Dr. Tammy Riklin Raviv
rrtammy@ee.bgu.ac.il

Department of Electrical and Computer Engineering

Expertise
Image processing, computer vision, biomedical image analysis, machine learning

Objectives
In my laboratory, we develop algorithms and computational tools for the processing and analysis of biological and medical images. We mainly exploit Deep Neural Networks (DNNs) that are considered the most promising computational tools, nowadays. We perform a variety of studies related to the Magnetic Resonance Image (MRI) acquisition and enhancement, as well as brain imaging and microscopy imaging analysis, in an interdisciplinary collaboration with neuroscientists, clinicians, and biologists.

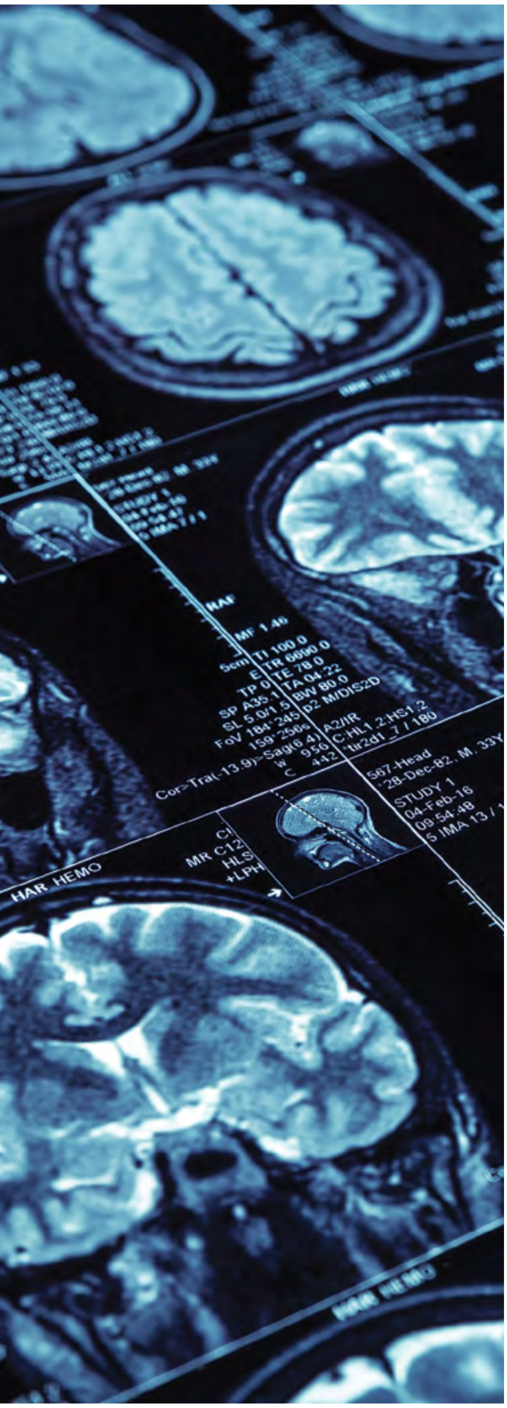
Description
A partial list of on-going projects includes:

- Cell segmentation and tracking in time-lapse microscopy images
- Acceleration of MRI acquisition by the reconstruction of sub-sampled images
- Denoising of Dynamic Contrast Enhanced MRI (DEC_MRI)
- Image enhancement and brain tissue segmentation
- Multi-dimensional co-segmentation of longitudinal brain MRI ensembles in the presence of a neurodegenerative process
- White-matter tract alignment and variability analysis for the assessment of mild brain impairments
- White-matter fiber tractography from diffusion tensor imaging
- Brain lesion and tumor segmentation in CT and MRI

Applications & Products
In most cases, we share the codes of our proposed algorithms (Python, Tensorflow) using github.

RELEVANT PUBLICATIONS

Please see:
https://scholar.google.co.il/citations?hl=en&user=xt7uyAEAAAAJ&view_op=list_works&sortby=pubdate



THEORY AND APPLICATION OF STATISTICAL LEARNING

Dr. Jonathan D. Rosenblatt
johnros@bgu.ac.il

Department of Industrial Engineering and Management

Expertise
Machine learning; statistics; medical imaging; distributed algorithms

Objectives
- Algorithms for scaling machine-learning to "bigdata" scale
- Applications in anomaly detection from sensor networks, medical imaging, psychology, geography, and economics
- Statistical theory and philosophical musings on the nature of "intelligence"

Description
Web-scale machine learning:
I study the statistical properties of large-scale machine learning algorithms, particularly distributed algorithms. This type of understanding allows for the identification of the "secret sauce" of successful algorithms, and for the design of new ones.
Examples include web-scale supervised learning, clustering, structure learning, active learning, etc.

Medical Imaging:
I design statistical tools and software for group studies of fMRI images. I am particularly interested in mapping scientific claims to statistical hypotheses, and designing the algorithm to verify these hypotheses.

Monitoring Systems:
Unlike Tableau or Power BI, my emphasis is on multivariate processes (e.g., IoT, sensor networks, etc.).
Our back-end is written in R. This allows us to implement cutting edge algorithms from various threads of literature: robust multivariate statistics, unsupervised machine-learning, and social-network analysis.
Our front-end is implemented in JavaScript (D3). This provides the interactivity, aesthetics, and efficiency of modern web-applications, and also allows our monitor/dashboard to run on desktops, tablets, and smart-phones.

RELEVANT PUBLICATIONS

Rosenblatt J.D., Benjamini, Y., Gilron R., Mukamel R., Goeman J. Better-Than-Chance Classification for Signal Detection. Accepted (pending minor revisions) to Biostatistics.

Vilensk, E., Bak P., **Rosenblatt, J.D.** 2019. Multivariate Anomaly Detection for Data Integrity in Dendrometer Sensor Networks. Accepted (pending minor revision) to Computers and Electronics in Agriculture.

Sarafian, R., Kloog, I., Just, A., **Rosenblatt, J.D.** 2019. Gaussian Markov Random Fields versus Linear Mixed Models for satellite-based PM2.5 assessment: Evidence from the Northeastern USA. Accepted to Atmospheric Environment.

Rosenblatt, J.D., Finos, L., Weeda, W.D., Goeman, J.J. 2018. All-Resolutions Inference for Brain Imaging. *NeuroImage*. Vol:181 p. 786-796

Gilron, R.S., **Rosenblatt, J.D.,** Oluwasanmi, K., Poldrack, R., and Mukamel, R. 2017. What's in a Pattern? Examining the Type of Signal Multivariate Analysis Uncovers to the Group Level. *NeuroImage*. Vol. 146. 113-120.

Rosenblatt, J.D., and Nadler, B. 2016. On the Optimality of Averaging in Distributed Statistical Learning. *Information and Inference*. Vol. 5, No. 4. p.379-404.

Rosenblatt, J.D. 2016. Multivariate revisit to 'sex beyond the genitalia.' *PNAS* Vol. 113 No. 14. p.E1966-E1967

RELEVANT PUBLICATIONS

Please see:
https://www.cs.bgu.ac.il/~sabatos/publications.html

INTERACTIVE MACHINE LEARNING

Prof. Sivan Sabato
sabatos@cs.bgu.ac.il, https://www.cs.bgu.ac.il/~sabatos/

Department of Computer Science

Expertise
Interactive machine learning

Objectives
My main area of research is theoretical machine learning. I focus on studying interactive settings, in which the algorithm is capable of selectively requesting information from the data source.

Description
Interactive learning algorithms include many types of interaction settings:

- Active learning, in which a classifier is learned while interactively obtaining a small number of labels
- Active feature selection, in which features are selected based on a small number of interactively obtained labels
- Learning with explanations, in which additional feedback on the reason for the label is provided and guides the learning algorithm
- Learning with relevance information, in which feedback on the importance or relevance of parts of the data set are provided and guide the learning algorithm

Applications & Products
Security and anomaly detection applications and automatic defect classification.
For published code see https://www.cs.bgu.ac.il/~sabatos/code.html

ADVANCED ANALYTICAL AND DECISION-SUPPORT SYSTEMS IN MEDICINE

Prof. Yuval Shahar
Head of the Medical Informatics Research Center
yshahar@bgu.ac.il

Department of Software and Information Systems Engineering

Expertise
AI in medicine (automated patient management, temporal data mining and machine learning)

Objectives
- Automated provision of evidence-based, guideline-based decision support to care providers and to patients
- Temporal Data Mining and Machine Learning to discover new medical knowledge from longitudinal data
- Protection of medical devices from Cyber-Security attacks and from human errors, using machine-learning

Description
- Using a unique combination of a temporal-abstraction language and a respective temporal reasoning engine, and a clinical-guideline representation language and a respective guideline-application engine, we continuously manage chronic patients over long periods. We provide automated, context-sensitive decision support to care providers in the clinical ward or the ambulatory clinic, and to patients at home (based on local sensors). Example: the €7M EU MobiGuide project.
- Using unique temporal data-mining algorithms, we provide clustering, classification, and prediction, given large numbers of time-oriented multivariate clinical data. The output also supports visual analytics and automated free-text summarization of the longitudinal clinical data.
- We created a new methodology and a unique computational architecture to protect medical devices from Cyber-security attacks or from human errors, by using machine-learning to learn from instructions sent to the device by a host controller or a human operator.

Applications & Products
- MiliMed Co. – Focuses on management of chronic patients at the hospital, clinic, and at home.
- CyberMed Co. – Focuses on protection of medical devices using machine learning.

RELEVANT PUBLICATIONS

Mahler, T., Shalom, E., Elovici, Y., and **Shahar, Y.** (2020). A dual-layer architecture for the protection of medical devices from anomalous instructions. Proceedings of the 2020 Conference on Artificial Intelligence in Medicine (AIME-2020).

Mahler, T., Elovici, Y., and **Shahar, Y.** (2020). A new methodology for information security risk assessment for medical devices and its evaluation. *arXiv:*2002.06938.

Goldstein, A., **Shahar, Y.**, Orenbuch, E., and Cohen, M. (2017). Evaluation of an automated knowledge-based textual summarization system for longitudinal, multivariate clinical data. *Artificial Intelligence in Medicine* 82:20–33.

Sheetrit, E., Nissim, N., Klimov, D., and **Shahar, Y**. (2019). Temporal probabilistic profiles for sepsis prediction in the ICU. In: Proceedings of The 25th ACM SIGKDD Conference on Knowledge Discovery and Data Mining (KDD-2019), Anchorage, Alaska, the USA. Winner of the *Audience Favorite Paper* award.

Shalom, E., **Shahar, Y.**, Parmet, Y., and Lunenfeld, E. (2015). A multiple-scenario assessment of the effect of a continuous-care, guideline-based decision support system on clinicians' compliance to clinical guidelines. *The International Journal of Medical Informatics* 84 (4):248- 262.

Peleg, M., **Shahar, Y.**, Quaglini, S., Fux, A., Garcia- Sanchez, G., Goldstein, A., González-Ferrer, A., Hernando, Jones, V., Klebanov, G., M.H., Klimov, D., Broens, T., Knoppel, D., Larburu, N., Marcos, C., Martinez-Sarriegui, I., Napolitano, C., Pallas, A., Palomares, A., Parimbelli, E., Rigla, M., Sacchi, L., Shalom, E., Soffer, P., and van Schooten, B. (2017). Assessment of a personalized and distributed patient guidance system. *The International Journal of Medical Informatics* 101:108-130.

ROBOTICS AND CONTROL LAB

Prof. Amir Shapiro, Associate Professor
ashapiro@bgu.ac.il, http://robotics.bgu.ac.il

Department of Mechanical Engineering

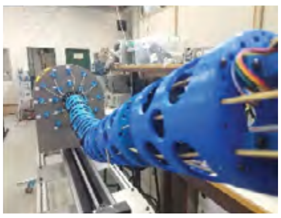
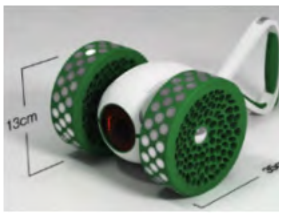
Expertise
Robots design and motion planning

Objectives
The Robotics Laboratory is a center for research and development of robotics technologies for various applications. The lab specializes in all aspects of robotics, ranging from mechanical design, through electronics development, to motion planning, state estimation, and control algorithms development.

Description
The technologies that are being developed in the lab are as follows:
1. Development of robotics platforms for ground and air applications
2. Development of motion planning algorithms for ground and air vehicles, both for single vehicle and for coordinated task completion
4. Stabilization of air vehicles and motion control both for air and ground vehicles
5. Gripper design, grasp planning and control, and objects manipulation planning
6. Motion planning and control robots





Applications & Products
Robot Grasp design for the e-commerce industry; hyper-redundant robot for inspection and car recharging; autonomous front-loader; wall climbing robots; and more.

RELEVANT PUBLICATIONS

Yoav Golan, Shmil Edelman, **Amir Shapiro,** and Elon Rimon. "Online Robot Navigation Using Continuously Updated Artificial Temperature Gradients." IEEE Robotics and Automation Letters 2, no. 3 (July 2017): 1280-1287

Avishai Sintov, Roland Menassa and **Amir Shapiro**. "A gripper design algorithm for grasping a set of parts in manufacturing lines". Mechanism and Machine Theory, Vol 105, 1-30, June 2016

A. Shapiro, I. Melzer, “Balance Perturbation System to Improve Balance Compensatory Responses During Walking in old Persons”, Journal of NeuroEngineering and Rehabilitation, Volume 7 (1): 32, July 2010.

ARTIFICIAL INTELLIGENCE: RATIONAL DECISION-MAKING

Prof. Eyal Shlomo (Solomon) Shimony
shimony@cs.bgu.ac.il, https://www.cs.bgu.ac.il/~shimony/

Department of Computer Science

Expertise
Decision-making under uncertainty

Objectives
Intelligent agents need to act in the real world, which is rife with uncertainty. Representing the uncertainty using probabilities allows one to use decision theory to make rational action choices. However, such models are typically intractable, and typical applications must also address limited computing resources and the need to act in a timely manner. Analyzing such issues and developing schemes that can handle these complications are our main objectives.

Description
Research in this domain requires advances in effective probabilistic reasoning in compact probability representations, such as Bayes networks. Definitions and solutions of compact decision-making models, such as factored Markov decision processes, are also needed. Our research develops such models and algorithms for effectively solving them, either exactly or approximately.

Solutions of these models are related to the domains of planning and search, which must also handle uncertainty in the world. These problems are typically intractable, so tradeoffs between optimality and timeliness must be made. Using techniques of rational meta-reasoning, we handle many such issues in temporal planning, real-time search, and algorithm selection.

In all these domains, and others, we balance a theoretical outlook – a formal complexity analysis of the underlying problems – with approximate or even heuristic solutions, verified empirically. The latter is usually done on applications such as optimizations of classifier learning for industrial partners, or AI in games competitions.

Applications & Products
Optimal Test Ordering in Cascade Architectures (US patent 8,175,999).

RELEVANT PUBLICATIONS

Shahaf S. Shperberg, Andrew Coles, Erez Karpas, **Solomon Eyal Shimony**, Wheeler Ruml: *Trading Plan Cost for Timeliness in Situated Temporal Planning.* IJCAI 2020: 4176-4182.

Shahaf S. Shperberg, Ariel Felner, **Solomon Eyal Shimony,** Nathan R. Sturtevant, Avi Hayoun: *Improving Bidirectional Heuristic Search by Bounds Propagation.* SOCS 2019: 106-114.

Erez Karpas, Oded Betzalel, **Solomon Eyal Shimony**, David Tolpin, Ariel Felner: *Rational deployment of multiple heuristics in optimal state-space search.* Artif. Intell. 256: 181-210 (2018)

Shahaf S. Shperberg, **Solomon Eyal Shimony**: *Some Properties of Batch Value of Information in the Selection Problem.* J. Artif. Intell. Res. 58: 777-796 (2017).

Daniel Berend , Ronen I. Brafman, **Solomon Eyal Shimony,** Shira Zucker, Shimon Cohen: *Optimal ordering of statistically dependent tests.* Discret. Appl. Math. 226: 17-31 (2017).

Shahaf S. Shperberg, **Solomon Eyal Shimony**, Ariel Felner: *Monte-Carlo Tree Search using Batch Value of Perfect Information.* UAI 2017.

Also see:
https://dblp.uni-trier.de/pers/s/Shimony:Solomon_Eyal.html

MODEL-BASED MACHINE LEARNING FOR SIGNAL PROCESSING AND COMMUNICATIONS

Dr. Nir Shlezinger, Senior Lecturer
nirshl@bgu.ac.il, https://sites.google.com/view/nirshl

Department of Electrical and Computer Engineering

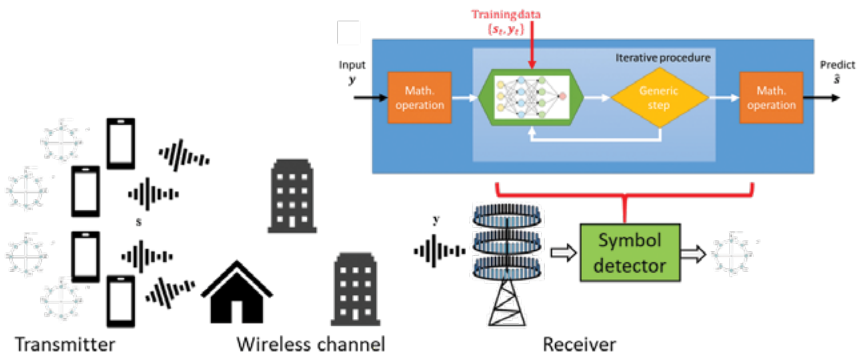
Expertise
Signal processing, machine learning, communications

Objectives

I study how deep neural networks (DNNs) can be combined with model-based algorithms. My goal is to enable model-based algorithms to be applied in scenarios for which these models cannot be applied directly, either because the underlying statistical model is highly complex or because insufficient knowledge of the system is available.

Description

Machine learning (ML) methods have demonstrated unprecedented empirical success in various applications, including computer vision and speech processing. The benefits of ML-driven techniques over traditional model-based signal processing approaches are twofold: First, ML methods are independent of the underlying stochastic model, and thus can operate efficiently in scenarios where this model is unknown, or where its parameters cannot be accurately estimated. Second, when the underlying model is extremely complex, ML algorithms have demonstrated the ability to extract and disentangle the meaningful semantic information from the observed data. Nonetheless, not every problem can – or should be solved using deep neural networks (DNNs). In fact, in scenarios for which model-based algorithms exist and are computationally feasible, as is the case for some signal processing and communications setups, these analytical model-based algorithm methods are typically preferable over ML schemes due to their performance guarantees and possible proven optimality.



Model-based deep learning-aided communication receiver

Applications & Products

Increased security of smartphones, UAVs, autonomous robots, and other IoT devices.

RELEVANT PUBLICATIONS

N. Shlezinger, N. Farsad, Y. C. Eldar, and A. J. Goldsmith, *ViterbiNet: A deep learning based Viterbi algorithm for symbol detection,* IEEE Transactions on Wireless Communications, 2020.

N. Shlezinger, N. Farsad, Y. C. Eldar, and A. J. Goldsmith, *Data-driven factor graphs for deep symbol detection,* arXiv, 2020.

N. Shlezinger, N. Farsad, Y. C. Eldar, and A. J. Goldsmith, *Inference from stationary time sequences via learned factor graphs,* arXiv, 2020.

WHAT IS YOUR STORY?

Dr. Armin Shmilovici
armin@bgu.ac.il

Department of Software and Information Systems Engineering

Expertise
Machine learning

Objectives
Making the computer understand the human experience as presented in cinema movies: what motivates humans, their relationships with other people, their emotions and feelings, etc.

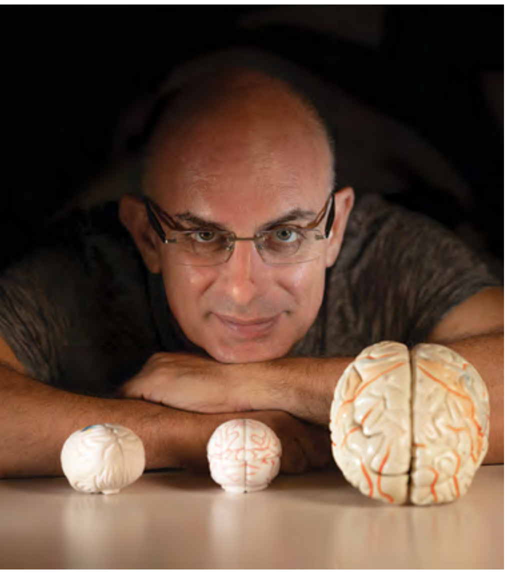
Description
Using datasets of movies or cartoons, we teach computers to detect key elements in the story, such as the main characters, their emotions, their motivations, and the typical narrative of the story.

Applications & Products
Developing embodied (robots) and non-embodied (computer interfaces) systems that can better observe and understand human motivations and, therefore, better communicate with computer-illiterate humans.

RELEVANT PUBLICATIONS

C. Liu, **A. Shmilovici,** M. Last (2020), “Towards story-based classification of movie scenes”, PLoS One. 2020, Vol. 15, No. 2, https://doi.org/10.1371/journal.pone.0228579

C. Liu, M. Last, **A. Shmilovici** (2019), "Identifying turning points in animated cartoons”, Expert Systems with Applications.



MACHINE LEARNING FOR ANALYZING BRAIN ACTIVITY

Dr. Oren Shriki
shrikio@bgu.ac.il

Department of Cognitive and Brain Sciences

Expertise
Computational neuroscience and analysis of neural data

Objectives
Research in my lab uses mathematical analyses of brain activity and machine learning algorithms to develop novel diagnostic tools for neurological and psychiatric disorders. In addition, the lab develops brain-computer interfaces for people with disabilities.

Description
The field of neurotechnology is quickly growing around the world. Wearable EEG devices allow us to monitor brain activity of patients and healthy individuals during their daily lives. We develop algorithms for analyzing these data in order to provide better diagnosis of brain-related disorders, but also to help boosting the neurowellness of healthy individuals. The analysis typically involves three consecutive stages: preprocessing, extraction of informative features that reflect the underlying brain dynamics, and application of machine learning algorithms.

We developed a system that simultaneously trains multiple machine learning algorithms, optimizes their hyper-parameters using Bayesian techniques and builds an optimal ensemble. The system also includes built-in tools for interpretability, which help reverse engineer the algorithms and explain their decisions. This is particularly important in the medical field when the output of such a system supports critical decisions of clinicians.

Applications & Products
NeuroHelp – A wearable EEG device for patients with epilepsy, which detects seizures and provides advanced alerts around an hour before a seizure. The NeuroHelp startup recently won the first prize in the SilicoNegev startup competition.

NeuroFalcon – A pilot helmet with embedded EEG sensors for monitoring the pilot brain and providing relevant alerts. This project, which is pursued in collaboration with the Israeli Air Force, focuses on several flight-related phenomena such as G-induced loss of consciousness, spatial disorientation and hypoxia, but also on more general domains such as cognitive workload and sleep deprivation.

FreeMind – A brain-computer interface to enable communication for patients with ALS. The system uses machine learning techniques to decode the patient's intent. A major effort in this project is to overcome the daily changes in neural representations, which require recalibration of the algorithms. In addition, the system is designed to provide a solution for completely locked-in patients, who cannot communicate in any other way.

RELEVANT PUBLICATIONS

Friedman N., Fekete T., Gal K., **Shriki O.**, EEG-based Prediction of Cognitive Load in Intelligence Tests, Frontiers in Human Neuroscience, 2019.

Abu-Rmileh A., Zakkay E., Shmuelof L. and **Shriki O.**, Co-adaptive training improves performance in a multi-day EEG-based motor imagery BCI training. Frontiers in Human Neuroscience, 2019.

Dotan A. and **Shriki O.**, An Entropy Maximization Approach to Optimal Dimensionality Reduction., 2018 International Joint Conference on Neural Networks (IJCNN), IEEE, 2018.

Shriki O. and Yellin D., Optimal Information Representation and Criticality in an Adaptive Sensory Recurrent Neural Network. PLoS Computational Biology 12(2), 2016.

EVOLUTIONARY ALGORITHMS MACHINE LEARNING

Prof. Moshe Sipper
sipper@bgu.ac.il, www.moshesipper.com

Department of Computer Science

Expertise
Evolutionary algorithms, machine learning, artificial intelligence

Description
I focus on artificial intelligence (AI) with applications to solving complex problems in different domains. I develop computational methods, such as genetic programming, which are inspired by how nature solves problems. I have published research on the use of AI in various domains, including software engineering, games, and biomedicine. I have recently developed novel collaborative algorithms to aid in the automation of learning — OMNIREP and SAFE. I am also developing other novel machine learning algorithms.

Applications & Products
Some of my software is available at https://github.com/moshesipper

RELEVANT PUBLICATIONS

M. Sipper, and J. H. Moore, Genetic programming theory and practice: A fifteen-year trajectory, *Genetic Programming and Evolvable Machines,* 2020.

M. Sipper, J. H. Moore, and R. J. Urbanowicz, New pathways in coevolutionary computation, *GPTP* 2019.

M. Sipper, J. H. Moore, and R. J. Urbanowicz, Coevolving Artistic Images Using OMNIREP, *EvoMUSART* 2020.

M. Sipper, and J. H. Moore, OMNIREP: Originating meaning by coevolving encodings and representations, *Memetic Computing,* 2019.

M. Sipper, J. H. Moore, and R. J. Urbanowicz, Solution and fitness evolution (SAFE): A study of multi-objective problems, *CEC* 2019

M. Sipper, J. H. Moore, and R. J. Urbanowicz, Solution and fitness evolution (SAFE): Coevolving solutions and their objective functions, *EuroGP* 2019.

J. H. Moore, R. S. Olson, Y. Chen, and **M. Sipper**, Automated discovery of test statistics using genetic programming, *Genetic Programming and Evolvable Machines,* 2019.

M. Sipper, R. J. Urbanowicz, and J. H. Moore, To know the objective is not (necessarily) to know the objective function, *BioData Mining,* 2018.

M. Sipper, W. Fu, K. Ahuja, and J. H. Moore, Investigating the parameter space of evolutionary algorithms, *BioData Mining,* 2018.

For additional publications, see: www.moshesipper.com

SEARCH AND PLANNING FOR MULTIPLE AGENTS

Dr. Roni Stern
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Department of Software and Information Systems Engineering

Expertise
Heuristic search, automated planning, multi-agent planning, automated diagnosis, automated debugging

Objectives
I am interested in developing algorithms for solving real-world problems that require Artificial Intelligence techniques, and developing basic theory and algorithms in this field. In particular multi-agent planning, automated diagnosis and troubleshooting, and heuristic search.

Description
Multi-agent planning: This sub-field of AI deals with how to automatically plan for a team of agents collaborating to achieve a mutual goal. Example applications include path planning for multiple robots or autonomous vehicles so that they do not collide. Another example is when a team of agents collaborate to perform logistics tasks, e.g., pickup and delivery of packages.

Automated diagnosis and troubleshooting: This sub-field of AI deals with how to automatically identify and isolate failures in a given system. For example, consider a vehicle behaving abnormally. An automated diagnostic algorithm will collect information about that vehicle and output suggested components that need to be replaced to correct the system. Another example is in software, where, if a program is behaving incorrectly, a diagnostic algorithm will identify which method or function is faulty and is causing this behavior.

Heuristic search: Many problems in AI, and in general, can be modeled as a problem of searching in a large discrete state space. The subfield called heuristic search deals with algorithms that search a large state space in an efficient manner, guided by imperfect heuristics. There are applications of heuristic search in many AI tasks, including planning, learning, and natural language processing.

Applications & Products
- Path planning algorithms for multiple agents, where an agent can be a vehicle, a robot, or any mobile entity.
- Algorithms for automated software test generation and debugging.
- Algorithms for searching in social networks.

RELEVANT PUBLICATIONS

Multi-Agent Pathfinding: Definitions, Variants, and Benchmarks, by **Roni Stern**, Nathan Sturtevant, Ariel Felner, Sven Koenig, Hang ma, Thayne Walker, Jiaoyang Li, Dor Atzmon, Liron Cohen, T.K. Satish Kumar, Eli Boyarski, and Roman Bartak. In the Symposium on Combinatorial Search (SoCS), 2019.

Probably bounded suboptimal heuristic search, by **Roni Stern**, Gal Dreiman, and Richard Valenzano. In Artificial Intelligence (AIJ), 2019.

Safe Partial Diagnosis from Normal Observations, by **Roni Stern** and Brendan Juba. In the AAAI conference on Artificial Intelligence.

Efficient, Safe, and Probably Approximately Complete Learning of Action Models, by **Roni Stern** and Brendan Juba. In the International Joint Conference on Artificial Intelligence (IJCAI), 2017.

How many diagnoses do we need? by **Roni Stern**, Meir Kalech, Shelly Rogov, and Alexander Feldman. In Artificial Intelligence (AIJ), 2015.

ALGORITHMS FOR DEMOCRACY

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Department of Industrial Engineering and Management

Expertise
Multi-agent systems

Objectives
My research is concentrated on designing efficient algorithms for multiagent collaboration, using techniques from computational social choice, voting theory, and combinatorial optimization.

Description
Bot societies, similar to human societies, share the need to communicate and, specifically, to reach common decisions. Research in game theory, political science, and economics has advanced our understanding of such mutual decision mechanisms. In my research, I aim to push the boundaries of what is possible to achieve using such mechanisms, and apply novel mechanisms to different applications that are useful to bot societies and human societies.

Applications & Products
Major applications are committee selection, participatory budgeting, and crowdlaw. Further applications are Sybil-resilient social choice and identification of Sybils in social networks.

RELEVANT PUBLICATIONS

Ouri Poupko, Gal Shahaf, Ehud Shapiro, **Nimrod Talmon**: Sybil-Resilient Conductance-Based Community Growth. Computer Science – Theory and Applications. CSR 2019. Lecture Notes in Computer Science, vol 11532. https://doi.org/10.1007/978-3-030-19955-5_31.

Piotr Faliszewski, **Nimrod Talmon**: A Framework for Approval-based Budgeting Methods. AAAI 2019, Vol 33(1).

Markus Brill, **Nimrod Talmon**: Pairwise Liquid Democracy. IJCAI 2018.

Piotr Faliszewski, Rica Gonen, Martin Koutecký, Nimrod Talmon: Opinion Diffusion and Campaigning on Society Graphs. IJCAI 2018.

COMPUTATIONAL STATISTICS AND MACHINE LEARNING

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Department of Electrical and Computer Engineering

Expertise
Machine learning, statistics, optimization

Description
My interests include (1) the application of advanced Machine Learning tools to Online Social Networks, to deepen the understanding of users' interactions in such networks. (2) Basic research in statistics and machine learning with a focus on computational-statistical trade-offs in non-convex optimization problems that arise frequently when dealing with high-dimensional data (e.g., sparse PCA). (3) Natural language processing and, in particular, various applications of word2vec; e.g., in a recent project, we developed a new, generic approach for the task of automatic Machine Translation quality estimation.

Applications & Products
In an on-going project that I am advising, the students have developed a voice-only depression detection app. The technology is based on careful voice analysis and machine learning. The app will soon be incorporated into a large-scale clinical trial for a proof of concept.

In another project, I am collaborating with an Israeli biotech company whose goal is to increase the ratio of female chicks in the eggs industry, where male chicks are currently being disposed of. To this end, we are using machine learning to find optimal hatching configurations.

RELEVANT PUBLICATIONS

Hershcovits H., **Vilenchik, D.**, and Gal K. 2019. Modeling Engagement in Self-Directed Learning Systems using Principal Component Analysis. IEEE Transactions on Learning Technologies.

Vilenchik, D., Yichye, B., and Abutbul, M. 2019. To interpret or not to interpret PCA? This is the question. Proceedings of the 13th International AAAI Conference on Web and Social Media.

Neuman Y., **Vilenchik D.** 2019. Modeling Small Systems through the Relative Entropy Lattice. IEEE Access.

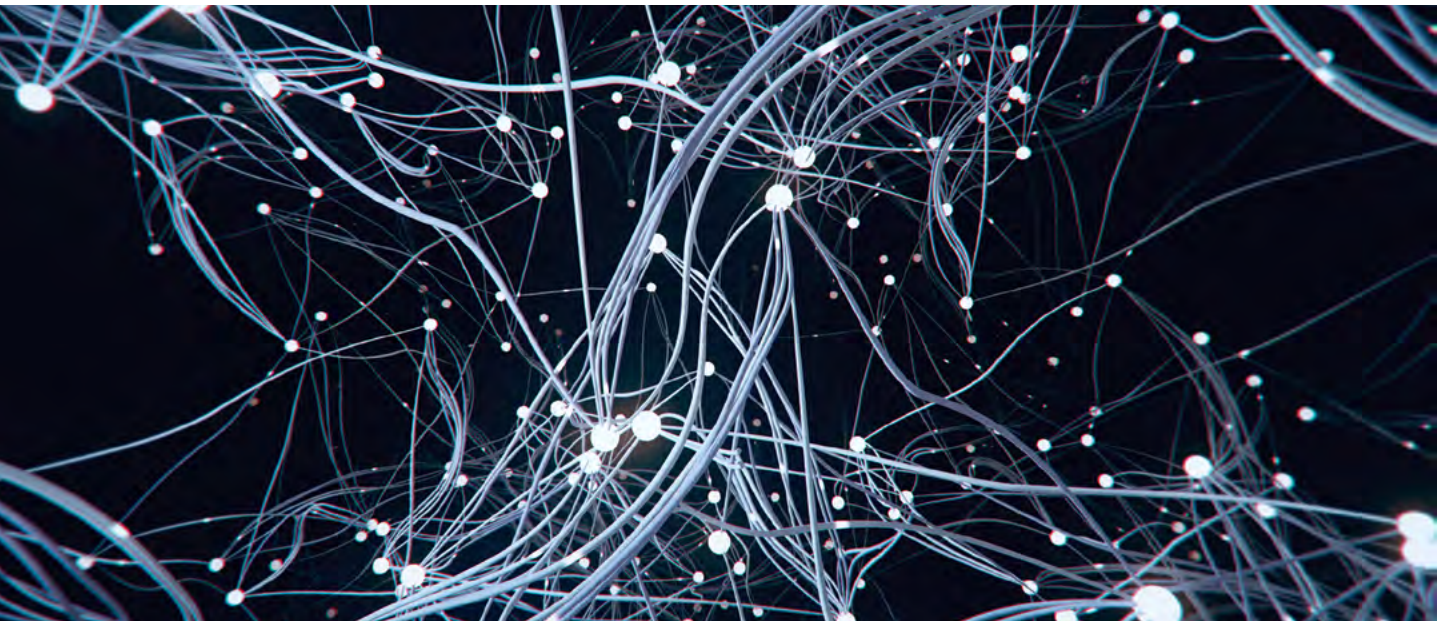
Vilenchik D. 2019. Simple statistics are sometime too simple: A case study in social media data. IEEE Transactions on Knowledge and Data Engineering.

Vilenchik, D. 2018. The Million Tweets Fallacy: Activity and Feedback are Uncorrelated. Proc. The 12th International AAAI Conference on Web and Social Media (ICWSM)

Neuman Y., Israeli, N., **Vilenchik, D.,** and Cohen, Y. 2018. The Adaptive Behavior of a Soccer Team: An Entropy-Based Analysis. Entropy.

Sofer, C., **Vilenchik , D.,** Dotsch, R., and Avidan, G. 2018. Emotion Algebra reveals the richness of meanings of facial expressions. Journal of Vision.

Krauthgamer, R., Nadler, B., and **Vilenchik, D.** 2015. Do Semi-Definite Relaxations Solve Sparse PCA up to the information limit? The Annals of Statistics.



AI ENHANCED BEHAVIORAL PROGRAMMING

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Department of Computer Science

Expertise
Machine learning, statistics, optimization

Objectives
Our research objective is to examine the possibility of enhancing Behavioral Programming (BP) with different AI-based idioms and show that these, with adequate analysis and execution algorithms, give power to programmers and can enhance their productivity. We believe that, with "correct" coding idioms, it will be possible to augment different algorithms with domain-specific knowledge in a natural and intuitive way, thus simplifying and enhancing programming.

Description
A key challenge in the design and development of reactive systems, whose role is to maintain an ongoing interaction with their environment, is coping with the huge variety of scenarios that may arise when the agent runs in a rich nondeterministic environment while acting optimally within its specifications bounds. Such specifications can be sometimes partial or vague.

Scenario-based specification and programming techniques cope with the abovementioned challenge by providing engineers with tools to specify independent patterns and anti-patterns of behavior that are interweaved at run-time to match the actual scenario that the agent has to deal with. This approach has proven to be useful in a variety of application domains. A key feature of behavior-based specifications is that the resulting specification is often non-deterministic in the sense that it gives the agent “freedom of choice” in situations where the library of patterns is not complete.

Since it is desirable to be able to explore executions of the models, our research focuses on enabling system programmers to translate their partial and vague specifications in a natural way to scenarios and behaviors using concepts from the Behavioral Programming (BP) approach and enhance it with different AI-based idioms. BP allows the use of use-cases and scenarios for the actual coding of software (executable specifications). Specifically, it introduces scenario coding techniques and design approaches for constructing reactive systems incrementally from their desired and undesired behaviors. By integrating AI, the system can explore executions of the models and perform optimally, while remaining in the bounds of its specifications and improving its efficiency. In addition, by maintaining vague and partial specifications, the system programmers can allow the execution mechanism different levels of autonomy.

RELEVANT PUBLICATIONS

Elyasaf A, Sadon A, **Weiss G, Yaacov T.** Using Behavioural Programming with Solver, Context, and Deep Reinforcement Learning for Playing a Simplified RoboCup- Type Game. In 2019 ACM/ IEEE 22nd International Conference on Model Driven Engineering Languages.

APPLIED RESEARCH IN SECURITY ANALYTICS AND THREAT MANAGEMENT

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Department of Software and Information Systems Engineering

Expertise
Information security

Objectives
Developing novel methods to identify and prevent advanced cyber threats.

Description
The primary research focus of Prof. Wolfsthal is the use of Artificial Intelligence (AI) and Machine Learning for protecting organizations from sophisticated cyber threats. Key directions addressed by this research include fraud prevention, user and entity behavior analytics, and system and network security. The research fosters collaborative innovation between industrial and academic experts, which serves to create strong, real-life, scalable results of high academic value, leveraging the latest innovations in AI.

Applications & Products
Research results, produced in collaboration between the scientific teams of IBM and Ben-Gurion University, have been integrated into IBM's security products.

RELEVANT PUBLICATIONS

TRusted Anonymous Data Exchange (TRADE) Threat Intelligence Sharing with Blockchain (SecurityIntelligence. Com, 2018).

“Visualizing Insider Threats: An Effective Interface for Security Analytics” (Proc. of 2017 ACM Conference on Intelligent User Interfaces).

"Cooperative Vehicle Monitoring and Anomaly Detection" (US Patent 2017-0200323A1).

3D SCENE ANALYSIS

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Department of Electro-Optics and Photonics Engineering
School of Electrical and Computer Engineering

Expertise
Image processing, imaging, computer vision

Objectives
Our main fields of research in the AI area include: 3D scene analysis, object detection and tracking under difficult conditions, and emotion identification.

Description

- We obtain 3D data of the in-front scene by a unique multi-view integral imaging camera, capable of producing computationally 3D object existence location information. This data is employed for 3D object segmentation and tracking. Depth-based object isolation is being developed to assist the production of vision capabilities for blind people.

- Detection and tracking of objects under difficult conditions includes cases of imaging through turbid atmospheric medium and quantifying dense livestock, among others. These conditions require unique consideration in the modeling. We have recently developed an online spatio-temporal action detection method in long-distance horizontal imaging, and a machine vision system for detecting and counting laying hens in battery cages.

- Human emotion identification is performed via fusion of several imaging bands (visual, NIR and thermal). Data obtained experimentally for physical body responses to induced emotions are uniquely enhanced, and machine learning is employed to identify the emotions.

RELEVANT PUBLICATIONS

O. Geffen, **Y. Yitzhaky**, N. Barchilon, S. Druyan and I. Halachmi (2020) “A machine vision system for detecting and counting laying hens in battery cages”, *Animal*. 14 (12): 2628-263. DOI: https://doi.org/10.1017/S1751731120001676.

DATA SCIENCE IN BIOIMAGING

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Department of Software and Information Systems Engineering

Expertise
Data science in cell imaging, computational cell dynamics

Objectives
Motivated by fundamental questions in cell biology, my lab produces biological insights along with specialized analytic tools that reveal hidden patterns in dynamic cell imaging data. We are taking an engineering approach, using a broad computational toolbox from the fields of computer vision, machine learning, time series analysis, graph algorithms, and agent-based simulations to solve complex imaging-based biomedical problems.

Description
Interpretable deep learning for microscopy: Deep learning has emerged as a powerful technique to identify hidden patterns in complex cell imaging data, but it is criticized as uninterpretable - lacking the ability to provide meaningful explanations for the cell properties that drive the machine's prediction. We "reverse engineered" a neural network to identify the cellular information that distinguishes very aggressive from less aggressive metastatic cells by artificially amplifying subtle cellular features that critically define the metastatic efficiency of a melanoma tumor. This technique may have broad applications for cancer and other diseases.

Defining the building blocks of collective cell behavior: How do multicellular patterns emerge from the heterogeneous behavior and interactions of individual cells? We are developing computational tools to measure cell behavior and cell–cell information transfer in dynamic multicellular systems, and we use these tools to decipher emergent collective cell behavior in a variety of biological systems: cell–cell mechanical communication through the ECM, collective cell death, multicellular calcium synchronization, and collective cell migration. Potential future applications include tissue engineering and drug screening.

Inference of combinatorial drug therapy with microscopy-based phenotypic drug screening and generative neural networks: High-content imaging-based drug screening is emerging as a powerful approach to probe disease complexity and discover potential treatments. We are developing a new computational approach that will enable mechanistic interpretability of the effects each drug has on specific aspects of cell organization to predict combinations and dosages of FDA-approved drugs that will synergistically provide precise and effective treatment.

Applications & Products
Potential applications span from predicting the metastatic efficiency of a tumor, to high-content imaging-based drug screening, and in vitro fertilization.

RELEVANT PUBLICATIONS

Nahum A, ..., Lesman A§, Zaritsky A§. Quantifying cell-cell mechanical communication through fibrous environments. bioRxiv 2020.

Zaritsky A. et al. Interpretable deep learning of label-free live cell images uncovers functional hallmarks of highly-metastatic melanoma. bioRxiv 2020.

Riegman M, ..., Zaritsky A§, Overholtzer M§. Ferroptosis occurs through an osmotic mechanism and propagates independently of cell rupture. Nature Cell Biology 2020.

Zaritsky A. Sharing and reusing cell image data. MBoC 2018.

Zaritsky A. et al. Diverse roles of guanine nucleotide exchange factors in regulating collective cell migration. JCB 2017.

Zaritsky A. et al. Decoupling global biases and local interactions between cell biological variables. eLife 2017.

Zaritsky A. Cell biologists should specialize, not hybridize. Nature 2016.

MULTI-AGENT OPTIMIZATION

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Department of Industrial Engineering and Management

Expertise
Distributed and multi agent models and problem solving

Objectives
My main interest is in solving problems that are naturally distributed. Recent advances in technologies and the world wide web have resulted in many problems that do not rely on a single machine and require a number of processes (agents) to collaborate in order to solve them. When agents are cooperative, these problems can be solved by Distributed Constraints Reasoning methods, which find solutions while avoiding data centralization. When the agents are self-interested, there is a need to incentivize them to perform cooperatively and participate in the solving process. I believe that people are never either completely cooperative or non-cooperative, and thus, part of my efforts are in designing partial cooperative models to capture natural human behaviors by agents, and algorithms for solving them.

Description
My research efforts are divided into three threads:
- Algorithmic: Design of distributed algorithms for solving Distributed Constraint Optimization problems (DCOPs).
- Partial Cooperation: Designing models that represent the intentions of people to cooperate with each other, and distributed algorithms that optimize under the cooperation assumptions of the model.
- Adapting distributed models and algorithms to realistic multi-agent applications.

Applications & Products
DDD – Dynamic Distributed Dispatch: A distributed task allocation algorithm that applies to heterogeneous scenarios including temporal and spatial constraints, and where cooperation is required and the needs may differ for different tasks.

DCOP_MST: An extension of the DCOP model for representing problems, including mobile sensing agents (robots), and distributed solving algorithms.

Smart Home Coordination: A distributed model and algorithms for scenarios in which smart meters in homes need to cooperate with the operation of electric devices in order to reduce pollution and make economic use of resources.

RELEVANT PUBLICATIONS

Balancing exploration and exploitation in incomplete Min/Max-sum inference for distributed constraint optimization, Journal of Autonomous Agents and Multi Agent Systems(JAAMAS), volume 31(5), pages 1165-1207. **Roie Zivan,** Steven Okamoto, Tomer Parash, Liel Cohen, Hilla Peled.

Privacy Preserving Implementation of the Max-Sum Algorithm and its Variants [pdf]. Journal of Artificial Intelligence Research (JAIR), volume 59, pages 311-349. Tamir Tassa, Tal Grinshpoun and **Roie Zivan.**

Incentivizing Cooperation between Heterogeneous Agents in Dynamic Task Allocation [pdf]. AAMAS 2017. Sofi Amador Nekle and **Roie Zivan.**

Max-sum Revisited: The Real Power of Damping [short pdf].AAMAS 2017. Liel Cohen and **Roie Zivan.**

EXPLAINING UNSUPERVISED MODELS' RESULTS

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Department of Software & Information Systems Engineering

Expertise
Data science

Objective
Explaining anomalies detected by autoencoders using SHAP

Description
Deep learning algorithms for anomaly detection, such as autoencoders, point out the outliers, saving experts the time-consuming task of examining normal cases in order to find anomalies. Most outlier detection algorithms output a score for each instance in the database. The top-k most intense outliers are returned to the user for further inspection; however, the manual validation of results becomes challenging without additional clues. An explanation of why an instance is anomalous enables the experts to focus their investigation on the most important anomalies and may increase their trust in the algorithm.

Recently, a game theory-based framework, known as SHapley Additive exPlanations (SHAP), has been shown to be effective in explaining various supervised learning models. In this study, we extend SHAP to explain anomalies detected by an autoencoder, in an unsupervised model. The proposed method extracts and visually depicts both the features that most contributed to the anomaly and those that offset it. A preliminary user study, using real-world data, demonstrates the usefulness of the proposed method in assisting the domain experts to understand the anomaly.

Applications & Products
Fraud detection in warranty claims, financial activities.

RELEVANT PUBLICATIONS

Friedman Antwarg, Liat, Shapira, Bracha and Rokach, Lior. 2019. Explaining Anomalies Detected by Autoencoders Using SHAP. arXiv:1903.02407

IMPLEMENTATION OF DISTRIBUTED ALGORITHMS ON A ROBOT TEAM

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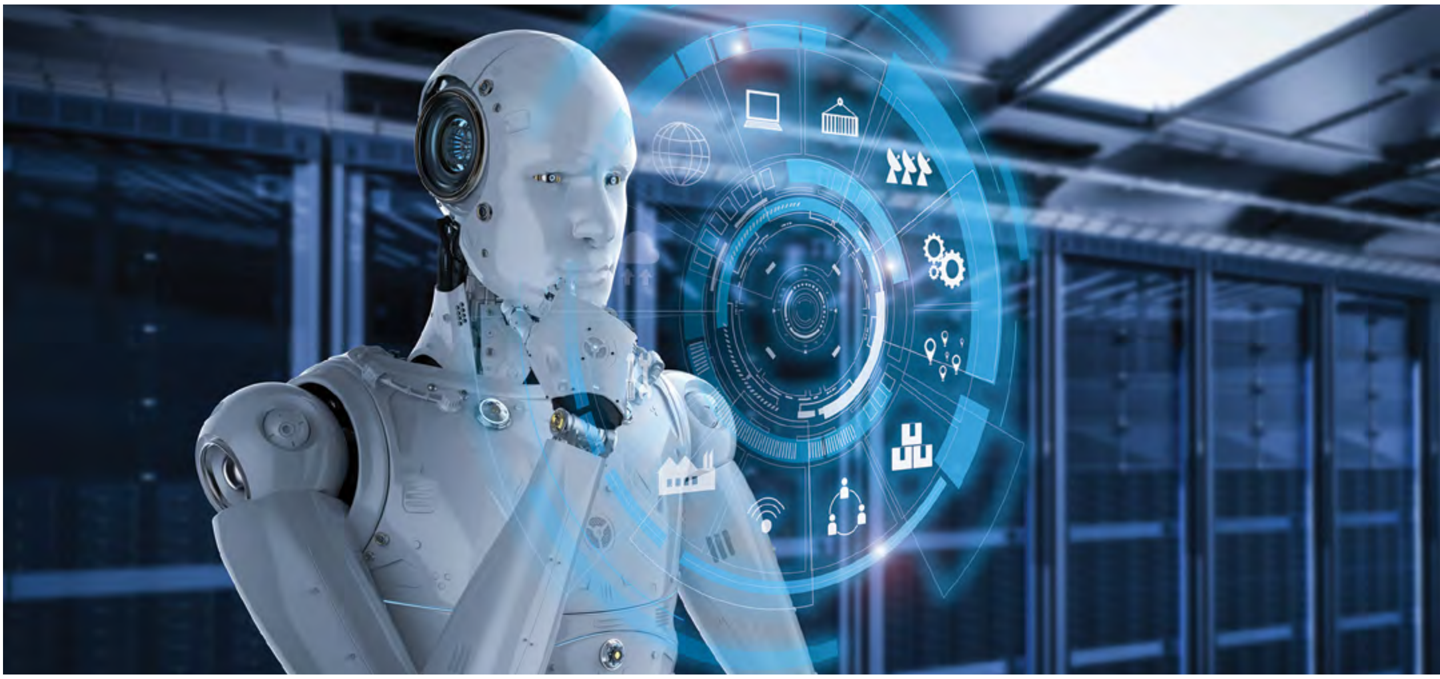
Advisor
Dr. Roie Zivan, zivanr@bgu.ac.il

Department of Industrial and Engineering Management

Expertise
Research in AI, RL, ML



Objectives
We are trying to bring intelligent behavior of distributed algorithms to the world of real robots. Our field is research in AI and we are working with Distributed Constraint Optimization Problems (DCOP) applied on Mobile Sensor Teams (MST).

Description
The implementation of algorithms is not a trivial task and it demands understanding in many correlated fields, such as robotics, robotic operation systems (ROS), and programming of distributed systems, among others.

Applications & Products
Efficient police surveillance in cities, autonomous robot surveillance in agricultural fields, maintaining the work of several robots in disaster areas, various discoveries of new targets in unknown areas (e.g., Mars), and more.

MULTIMODAL MACHINE LEARNING FOR DRUG KNOWLEDGE DISCOVERY

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Expertise
Artificial intelligence and machine learning in the medical, cybersecurity, and geographic domains

Objectives
Multimodal learning and representation learning using various data sources. Applying AI methods to drug knowledge and expanding it. I am interested in applying AI and machine learning in the medical, geographic, and cybersecurity fields.

Description
Multimodal machine-learning is gaining research interest due to its relevance in many fields. Nevertheless, in most cases, the research focuses on unstructured data such as video, audio, and text. I investigate how multimodal learning can be improved for structured data and assess the proposed solutions using drug-related data, thereby expanding drug-related knowledge. I recently published a novel method for drug interaction prediction. Drug–drug interactions are preventable causes of medical injuries and often result in doctor and emergency room visits. Using my method, I published one hundred currently unknown drug interactions.

My previous works include approaches for virtual permission learning for file systems. The approach eploys unsupervised machine learning to dynamically learn peer groups. Once these peer groups are learned, they are used to determine appropriate virtual permissions for which users should or should not be allowed to access files within an organization, thus allowing anomaly detection in file systems.

Another study presented a method for continuous indoor–outdoor environment detection on mobile devices based solely on Wi-Fi fingerprints.

RELEVANT PUBLICATIONS

Papers:
Shtar, G., Shapira, B., & Rokach, L. Clustering Wi-Fi fingerprints for indoor–outdoor detection. Wireless Networks (2019) 25: 1341. https://doi.org/10.1007/s11276-018-1753-9.

Shtar, G., Shapira, B., & Rokach, L. Detecting drug-drug interactions using artificial neural networks and classic graph similarity measures. https://arxiv.org/abs/1903.04571.

Patents:
Shtar Guy, and Shiri Margel. "Insider threat detection utilizing user group to data object and/or resource group access analysis." U.S. Patent Application No. 16/254,520.

Shtar Guy, and Shiri Margel. "Insider threat detection utilizing user group data object access analysis." U.S. Patent Application No. 15/673,932.

COMPUTATIONAL CRIMINOLOGY AND USER MODELING

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Department of Software and Information Systems Engineering

Expertise
Computational criminology, user modeling, machine learning

Objectives
Computational criminology:
- Reduce the number of burglaries by enabling the police to focus their efforts on certain regions at specific times (i.e., when and where burglaries are predicted to occur).
- Extracting criminals' behavioral patterns in order to identify potential suspects with high probability for open burglary cases.

User modeling:
- Predicting human mobility and assess the confidence level of the predictions based on different users' attributes.
- Assessing users' information security awareness (ISA) for protecting systems and organizations from social engineering attacks.

Description
In the domain of computational criminology, we use machine learning methods for reducing the number of crimes by enabling the police to focus their efforts on certain regions at specific times. We also suggest an automatic and language independent method for extracting criminals' behavioral patterns. Our method mimics the process performed by a police investigator. Using our method, we were able to extract the MO from textual Hebrew police reports.

Our research also focus on user modeling; we offer different machine learning methods for learning users' behavioral pattern, thus, offering better personalized services. As part of our recent research we also suggest utilizing users' contextual factors for improving their security awareness.

Applications & Products
Machine learning models:
- DeePrison – A Deep Learning Framework For Predicting Burglaries Based on Multiple Contextual Factors.
- Extracting criminals' behavioral patterns from police reports.

RELEVANT PUBLICATIONS

Solomon, A., Magen, A., Hanouna, S., Kertis, M., Shapira, B., & Rokach, L. (2020, October). Crime Linkage Based on Textual Hebrew Police Reports Utilizing Behavioral Patterns. In Proceedings of the 29th ACM International Conference on Information & Knowledge Management (pp. 2749-2756).

Solomon, A., Bar, A., Yanai, C., Shapira, B., & Rokach, L. (2018, July). Predict demographic information using word2vec on spatial trajectories. In Proceedings of the 26th conference on user Modeling, adaptation and personalization (pp. 331-339).

REPRESENTATION OF DATASETS AND MACHINE LEARNING PIPELINES FOR METALEARNING AND AUTOML OPTIMIZATION

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Expertise
Data science, artificial intelligence and machine learning

Objectives
Automatic generation and selection of machine learning pipelines and models for a given machine learning problem.

Description
The widespread use of machine learning algorithms and the high level of expertise required to utilize them have fueled the demand for solutions that can be used by non-experts. There is a clear need for automated model discovery systems that enable users with subject matter expertise, but no data science background, to create empirical models of real and complex processes. One of the challenges of automated machine learning applications is the automatic selection of a machine learning pipeline and model for a given problem.

The main objective of our research is to develop novel and resource-efficient approaches for machine learning model/pipeline generation or selection. To achieve this objective, our approach combines several sources of information: meta-features extracted from the data itself, word-embedding features extracted from a large corpus of academic publications, graphical dataset representation (and analysis), and information (meta-features) regarding the candidate pipeline solutions.

Applications & Products
Automated machine learning tools and platforms

RELEVANT PUBLICATIONS

Cohen-Shapira,N. Rokach,L. Shapira,B. Katz,G. and **Vainshtein, R.** 2019. AutoGRD: Model Recommendation Through Graphical Dataset Representation. In Proceedings of the 28th ACM International Conference on Information and Knowledge Management (CIKM '19). Association for Computing Machinery, New York, NY, USA, 821–830

Vainshtein, R., Greenstein-Messica, A., Katz, G., Shapira, B., & Rokach, L. (2018, October). A hybrid approach for automatic model recommendation. In Proceedings of the 27th ACM International Conference on Information and Knowledge Management (pp. 1623-1626).

Laadan, D., **Vainshtein, R.,** Curiel, Y., Katz, G., & Rokach, L. (2020, October). MetaTPOT: Enhancing A Tree-based Pipeline Optimization Tool Using Meta-Learning. In Proceedings of the 29th ACM International Conference on Information & Knowledge Management (pp. 2097-2100).

ABOUT BGN TECHNOLOGIES LTD.

BGN Technologies is the technology transfer company of Ben-Gurion University of the Negev (BGU). BGN Technologies brings technological innovations from the lab to the market and fosters research collaborations and entrepreneurship among researchers and students. To date, BGN Technologies has established over 100 startup companies in the fields of Biotech, Hi-tech and Cleantech and initiated leading technology hubs, incubators and accelerators. During the past decade, BGN Technologies focused on creating long-term partnerships with multinationals such as Deutsche Telekom, Dell-EMC, Lockheed Martin and PayPal, securing value and growth for BGU and the Negev region.

http://in.bgu.ac.il/en/BGN

ABOUT BEN-GURION UNIVERSITY OF THE NEGEV

Ben-Gurion University of the Negev is the fastest growing research university in Israel. With 20,000 students, 4,000 staff and faculty members, and three campuses in Beer-Sheva, Sede Boqer and Eilat, BGU is an agent of change, fulfilling the vision of David Ben-Gurion, Israel's first prime minister, who envisaged the future of Israel emerging from the Negev. The University is at the heart of Beer-Sheva's transformation into the country's cyber capital, where leading multinational corporations leverage BGU's expertise to generate innovative R&D.

As it counts up to its fiftieth anniversary, BGU's mission continues to be effecting change, locally, regionally and internationally. With faculties in Engineering, Health Sciences, Natural Sciences, Humanities and Social Sciences, Business and Management, and Desert Studies, BGU is a university with a conscience, active both on the frontiers of science and in the community. Over a third of our students participate in one of the world's most developed community action programs. BGU is a recognized national and global leader in multiple fields, actively encouraging multi-disciplinary collaborations with government and industry, and nurturing entrepreneurship and innovation in all its forms.

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