Sustainable Precision Agriculture in the Era of IoT and Artificial Intelligence

July 18-20, 2023

Book of Abstracts

BARD AG-AI Workshop

Location: All Sessions will take place
at the Ben Gurion University Campus
in the W.A. Minkoff Senate Building (71A).

Workshop Program

Website link:
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For Sustainable Agriculture

Book of Abstracts

Arranged by Lecturer's First Name

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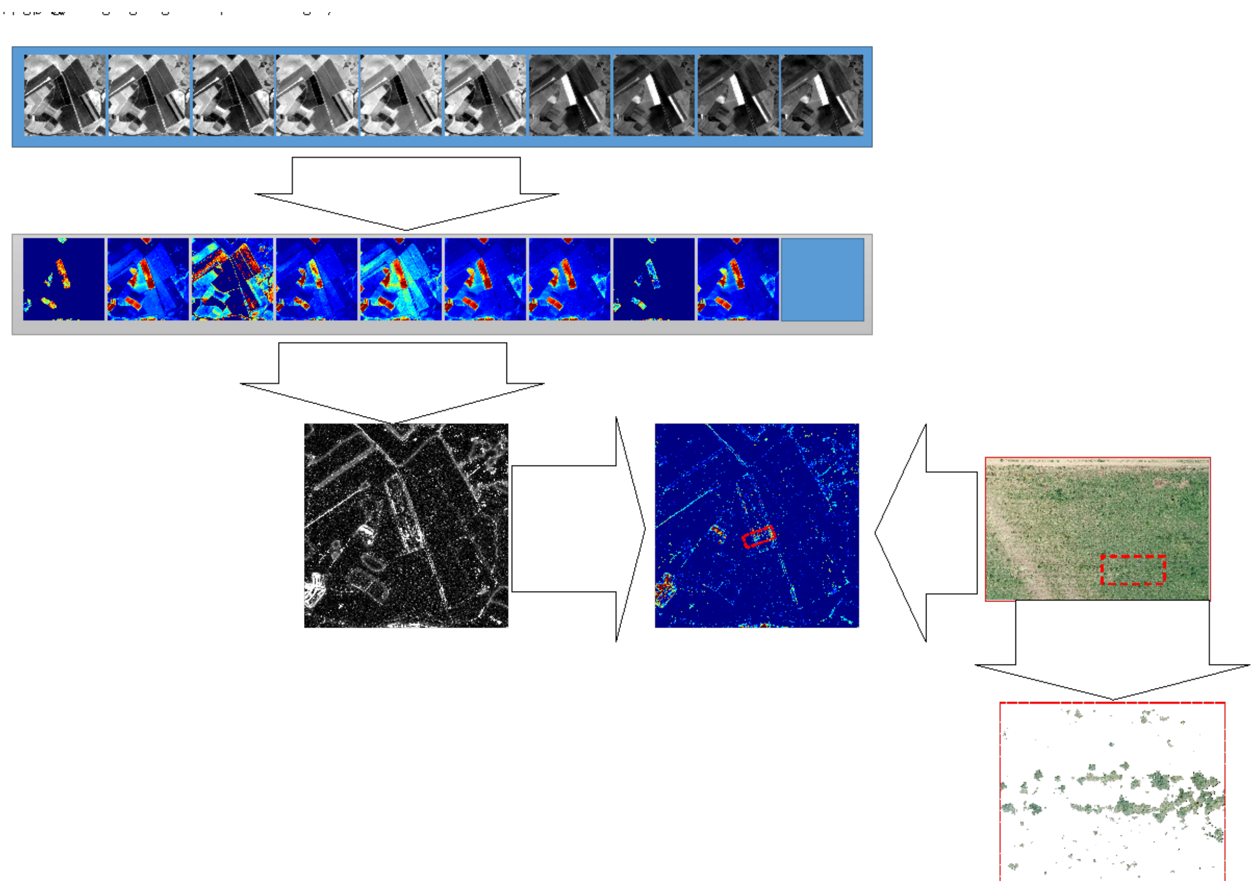
LECTURERS – arranged alphabetically by Lecturer’s First Name:

[1] Multisource Remote Sensing Sensors/Platforms Integration and Synergy in Smart and Sustainable Agriculture

Prof. Anna Brook - University of Haifa, Israel

Session D – Day 2

Climate change and global food security are major challenges for the agricultural sector. Precision agriculture is the key to optimizing food production in a sustainable way. This requires accurate and large-scale monitoring systems. In situ data are mostly collected as samples and reported as points in vector format. In practice, it is necessary to estimate the values in non-sampled areas using spatial prediction methods implemented in the geographic information system via geo-statistics tools. Remote sensing data and methods were successfully implemented in various applications within precision agriculture. Many applications are based on open and commercial satellite data for real-time monitoring of agricultural crops. Remote sensing techniques using machine learning algorithms on satellite data can periodically assess physical and biochemical parameters (soil and crop) on relatively coarse spatial resolution. Since, the machine learning algorithms are mostly based on visual features (patterns, edges etc.) the unmanned aerial systems (UAS) have produced alternative monitoring platforms that offer the opportunity to acquire spatial, spectral and temporal information in a wide range of agricultural applications at a relatively low cost. The most direct and important advantage of UAS is the ability to acquire high-resolution images, which, depending on the flight altitude and sensor spatial resolution, can reach a ground sampling distance of centimeters and even millimeters. Thus, the UAS-based remote sensing cannot cover as big an area as the satellite-based remote sensing. The collected thousands of individual overlapping images need to be processed and post-processed bringing challenges concerning computer storage, processing phases (creating orthomosaic and digital surface model) etc. The cloud service solves problems related to hardware and software, but it is still a bottleneck regarding the image upload and return. Most image processing algorithms are based on computer vision and developed as software libraries that are user friendly but not easy to modify, e.g. radiometric correction in agricultural applications. Our hybrid approach couples phenological processes with the versatility of data-driven machine learning to better understand the dynamic processes and agricultural responses to stressors, and emphasizing sustainability and decision support systems. The proposed monitoring system is designed as follows: 1) anomaly detection model (deep learning-based LSTM network) for satellite imagery, 2) anomaly verification and classification model (two separate CNNs connected in a cascaded fashion) for UAS imagery. Training of the cascaded model will be performed for each CNN individually; however, once the training will be completed for two CNNs, the anomaly classification model will operate as a fully automated end-to-end network. The anomaly classification CNN is adapted from Densely Connected Convolutional Networks (DenseNet) which has demonstrated reliable performance for image recognition. The combination of satellite and UAS-based sensor systems can improve the monitoring of agricultural areas by exploiting the strengths of each method. This can help to detect anomalies in plant growth and optimize crop health assessment, leading to better decision-making by farmers and ultimately improving food security. Therefore, the integration of satellite and UAS-based sensor systems has the potential to play a crucial role in addressing the challenges facing agriculture in the era of climate change and population growth. This can contribute to achieving the Sustainable Development Goals (SDGs) of zero hunger, responsible consumption and production, climate action and life on land.



Combining the strengths of multisource data provided a comprehensive monitoring system for detecting anomalies in plant growth, which can contribute to optimizing food production and meeting the challenges of climate change and food security.

[2] Integrating Biomarkers into the Electronic-Sensors based PLF Toolbox

Dr. Ariel Shabtay - Agricultural Research Organization, Volcani Institute, Israel

Session B (Part 1) – Day 1

Precision livestock production seeks to make use of large quantities of specific information about individual animals and locations to optimize performance. Precision livestock farming (PLF) utilizes continuous automated real-time monitoring to control production, reproduction, health and welfare of livestock. In addition, PLF can also be implemented to follow the effect of feeding regimes, such as integration of new feed stuffs or additives in the diet, on the individual's performance. Being non-invasive and of high throughput and in real-time capabilities, most of these monitoring systems exclusively involve the utilization of electronic sensing, with no additional input coming from the biochemical-physiological-genetic-behavioral systems. Biological samples from various sources such as saliva, hair, feces and blood are easily attained and can be indicative of metabolic states and disorders. Moreover, in combination with behavioral inputs that reflect temperament and social status, they can predict the vulnerability to future diseases. Based on a series of studies in suckling Holstein calves, showing the association of biomarkers with production, environmental impacts and prediction of disease susceptibility, it is suggested that an integrated biological markers-electronic sensors approach could add valuable components to the PLF tool box, leading to successful management decision making on farm. However, integrating biomarkers into a real-time online mode is still a great challenge.

[3] Early Detection of White Mold Disease in Field Crops via Remote Sensing and Machine Learning

Dr. Assaf Chen - MIGAL – Galilee Research Institute, Israel

Session D – Day 2

Soil-borne diseases in field crops pose a significant threat to crop yield. Since most soil fungal disease pesticide treatments are given as early prevention, before the onset of apparent disease symptoms, early detection of these diseases is essential for applying agro- technical solutions and deterrence material and reducing the number of treatments in disease-free areas. In this study, remote sensing tools were developed for the early detection of white mold disease (WMD) caused by the pathogen Sclerotium Rolfsii, which bring upon plant wilting. Commercial agricultural fields located in Hula valley (Israel), with a history of WMD were selected. Thermal, visible light (RGB) and near infra-red (NIR), multi and hyper-spectral aerial imagery were obtained using unmanned aerial vehicles. Plant health status and foliage intensity were estimated using the green-red vegetation index, produced from RGB. Plant and air temperatures were analyzed in order to locate infected areas and uncover field heterogeneity. Machine learning and deep learning algorithms (Random Forest and U-Net / YOLO-V5, respectively) were used to classify stressed plants caused exclusively by WMD, compared with other biotic/abiotic stress. Multispectral and hyperspectral sensing was also used in order to characterize the spectral signature of diseased plants, compared to healthy plants. The algorithms were developed in the Python language. Remotely sensed findings were validated with ground monitoring. U-net deep learning algorithm WMD yielded: Overall-Accuracy = 67.9%, Producer's accuracy = recall = 86%, User's accuracy = precision = 76.2%, and f1-score: 0.81 with the use of color and lighting augmentation. Random Forest machine learning algorithm with Feature selection = 20, which is based on hyperspectral sensing proved to be very successful with precision = 92%, recall = 91 %, F1-score = 0.92. Early detection of diseases may reduce pesticide application, and increase crop yield, thus achieving environmental and commercial advantages.

[4] Agricultural Robots and AI for Precision Agriculture

Prof. Avital Bechar- Agricultural Research Organization, Volcani Institute, Israel

Session A – Day 1

Robots are perceptive machines that can be programmed to perform specific tasks, make decisions and act in real time. They are required in various fields that normally call for reductions in manpower and workload, and are best-suited for applications requiring repeatable accuracy and high yield under stable conditions. However, they lack the capability to respond to ill-defined, unknown, changing, and unpredictable events. The technical feasibility of agricultural robots for a variety of agricultural tasks has been widely approved. Nevertheless, despite the tremendous amount of research, commercial applications of robots in complex agricultural environments are not yet available. Precision agriculture was first introduced some four decades ago. The techniques and research in precision agriculture were conducted to align with four main objectives: to increase agricultural productivity, increase produce quality, reduce production costs and reduce environmental impact. Until recently, research in the fields of agricultural robotics and precision agriculture evolved along parallel paths with little interaction or few relations between them. In my presentation I will show development of integrated approaches and operation concepts of both robotics and precision agriculture and include the creation of sophisticated, intelligent algorithms for sensing, planning, control and decision-making. I will present how the synergy between robotics precision agriculture and AI pave the way to smart agriculture and will present a few developments of an agricultural robot performing precision agriculture tasks.

[5] Integrating Topographic and Soil Survey Analyses into Predictions of Cover Crop Performance in Precision Sustainable Agriculture Models

Dr. Brian Needelman - University of Maryland, USA

Session B (Part 1) – Day 1

Topographic and soil variation within fields are important drivers of agroecosystem functions. Winter cover crops are a key precision sustainable agriculture practice to improve ecosystem services in croplands. Cover crop biomass can retain nitrogen that might otherwise be lost over winter and spring months, and nitrogen can become available for the subsequent cash crop as terminated cover crops decompose. In this presentation we will discuss a study that aims to uncover key sources of spatial heterogeneity in cover crop performance to inform models that optimize variable nitrogen fertilizer application rates within fields. We explore the ability of topography and soil survey data to explain variation in remotely sensed cover crop data from the Choptank watershed in the Delmarva peninsula, Maryland, USA. We use the U.S. National Soil Survey Geographic Database (SSURGO), which is composed of polygons containing one to five soil components, each of which is associated with a detailed database on soil properties. Findings from this project will be used to inform decision support tools for farmers through the Precision Sustainable Agriculture network. In this presentation we also discuss a current project in Israel to update and modernize Israeli soil survey and its potential to inform precision sustainable agriculture analyses and models.

[6] Emergence Agriculture: Concept for Managing Complexity in Maize Production

Prof. Charlie Messina - University of Florida, USA

Session D – Day 2 -Not Available

[7] Unmanned Aerial Systems for Plant-Stress Identification and Monitoring

Prof. Dharmendra Saraswat - Purdue University, USA

Session C (Part 2) – Day 2

Advances in sensor technology and decreasing cost of components have contributed to the affordability of unmanned aerial systems (UAS) for collecting image or video data from agricultural fields. There is a growing interest among researchers in using deep-learning algorithms, a subset of AI, to improve the capabilities of UAS for automating the task of identifying crop stressors. However, UAS use for automation in production agriculture is still early as annotated data required for training and testing deep learning models for agricultural stresses is limited. This talk will present an analysis and discussion on the performance of deep learning models for plant biotic stress identification and monitoring.

[8] Decision Support Tools for Farmers: Field Data Collection Challenges and Opportunities through Multidisciplinary Collaboration

Prof. Dorivar A. Ruiz Diaz - Kansas State University, USA

Session B (Part 2) – Day 1

Farmers take into account several factors when making decisions in the field. They carefully consider the cost of inputs and agronomic and environmental factors. Achieving the right balance requires utilizing the best available data for the specific farm. For instance, soil sampling and laboratory analysis are still considered the most reliable data source for fertilizer application guidelines. However, the in-season supply of certain nutrients, like nitrogen, may not be determined accurately with pre-season soil sampling, given the influence of soil and environmental conditions, which can be particularly challenging in some environments. Additionally, collecting actionable in-season data can present logistical challenges, be costly, and require timely execution. A combination of multiple data sources, including historical weather, soils, current management, weather forecast, and aided by crop models, may help improve our predicting capacity and improve current guidelines. To address these challenges, fostering closer collaboration among farmers, field agronomists, engineers, and computer scientists is essential. Through this collaboration, innovative solutions can be developed to provide practical decision-support tools that enhance profitability and promote environmental benefits, which are crucial for sustainability. However, farmers' acceptance of certain decision support tools remains a challenge; this presentation will provide a perspective from extension and applied agronomy, highlighting opportunities for multidisciplinary collaboration.

[9] Seasonal Predictions of Crop Yield under Changing Climate Conditions: The Coupled Crop-Climate Modeling Approach

Dr. Ehud Strobach - Agricultural Research Organization, Volcani Institute, Israel
Session C (Part 1) – Day 1

Knowing potential dryland field crop yield before harvest is invaluable for farmers, policymakers, and other stakeholders. Yet, this knowledge is still lacking and with a success that is typically limited to specific conditions and locations. While many external factors, such as management strategies, diseases, and pests, may influence crop development, these factors are usually related to particular fields and regions. Assuming that similar practices and treatments are applied at the regional scale, the main factor influencing year-to-year crop variability is climate conditions. Perhaps the most important factors are the soil moisture from precipitation that supplies water to the plant, short wave radiation that drives photosynthesis and surface temperature that determines the plant development stage. Accurate and reliable seasonal predictions of field crop yield, therefore, require a trustworthy representation of future climate variability. In recent years, it has been established that widely extended field crops are not only affected by climate conditions but can also change climate conditions above and around the crop, forming an interacting crop-climate feedback loop. This understanding motivated the establishment of global and regional climate models coupled with crop models in which the crop exchanges heat and water with the environment (atmosphere and soil). In this talk, I will review recent advances in seasonal climate predictions and crop-climate modeling. As part of this talk, the WRF-Noah-MP-Crop modeling system will be introduced, focusing on our current work to adjust the crop model parameters to the wheat cultivars grown in Israel. Preliminary results from the coupled system adjusted to Israel’s wheat cultivars will be presented, indicating a great potential for establishing a seasonal wheat yield prediction system for Israel.

[10] Agri-Light's Smart Ai Agri-PV System

Mr. Elisha Rubin - Agri-Light, Israel

Model Farm – Day 3

Agri-Light Energy Systems is an Israeli startup led by a diverse group of renewable energy, precision agriculture, environment and sustainability, and data analytics experts with extensive experience in the above stated fields. Agri-Light has developed its patented **"**Smart Agri-PV" (SAPV) system that utilizes innovative algorithms/machine learning, and its unique mechanical engineering design, to optimize and protect crop cultivation; while at the same time maximizing electricity generation. The core of the SAPV system is its "smart" optimization controller that automatically moves solar panels horizontally based on a multiplicity of data inputs (GIS, agronomic, sun azimuth, weather conditions, crop and soil type and sun/water needs); and in doing so optimally balances photosynthesis giving the right amount of sun and shade to improve crop cultivation and production without reducing photovoltaic effectiveness. SAPV is a modular system using ground screws (no cement) so as not to damage crops in its installation. In development is SAPV's Agri-Energy Smart Optimizer, a mobile application that will provide real time information and prediction to project owners and farmers based on the wide range of data inputted to its cloud-based system; and this will improve operational efficiency, decision making, and forecasting. Agri-Light has pilot opportunities today throughout Israel and several countries in Europe and Africa.

[11] Precision Agriculture: The Pedosphere under a Spectral Binocular

Prof. Eyal Ben-Dor -Tel Aviv University, Israel

Session E – Day 2

Soil provides ecosystem services, supports human health and habitation, stores carbon and regulates emissions of greenhouse gases. Unprecedented pressures on soil from degradation and urbanization are threatening the agro-ecological balance and food security. It is important that we learn more about soil to sustainably manage and preserve it for future generations. Soil is a complex system that is extremely variable in physical and chemical composition in space and time. It is formed from exposed masses of partially weathered rocks and minerals of the earth's crust. Soil spectroscopy across the VIS-NIR-SWIR-TIR (0.4-14μm) spectral region is less complex than the soil itself and hence can reduce the uncertain dimension of the soil system. Furthermore, a proxy data-mining approach for extracting spectral information that refers to soil attributes is possible and has gained much attention over the past decade in the precision agriculture discipline. A suitable data-mining AI based algorithm enables extracting a mixture of spectral information that is hidden in the spectrum: it cannot be seen or extracted with the naked eye or even by ordinary computation. As the spectral data-mining approach is statistically driven, a large set of samples ("big data") is required to establish a precise soil spectral model for a given soil attribute. Accordingly, over the last 5 years, extensive effort has been devoted in building, sharing and using soil spectral databases (also termed soil spectral libraries—SSLs) on national, continental and global scales. SSLs consist of metadata (location, geology, climate, topography, horizon, area description and location) plus chemical and physical attributes from wet laboratory analyses. This together with the soil spectral information the SSL is used to derive soil attributes from a complex system without having to bring it to the laboratory; as such, it is important for the forthcoming super spectral and hyperspectral sensors. As the soil spectral user community expands, the demand for large SSLs from many geographical areas on every scale intensifies. Thus, several regional SSLs have been evaluated (e.g., Africa, Brazil, USA and Europe) while more recently, a worldwide effort has been devoted to creating a global SSL. Recently a new era in space where hyperspectral sensors became operational, exploiting the SSLs for soil quantitative mapping takes an interesting direction. The current lecture will provide an updated overview of soil spectral analyses to foster soil monitoring under the precision agriculture era.

[12] AI-Based Muti-Sensor Data Fusion for Spatially Enhanced Spectral Mapping Products

Dr. Fadi Kizel - Technion - Israel Institute of Technology, Israel

Session E – Day 2

In the last decade, we have witnessed enormous progress in Artificial Intelligence (AI) techniques for various applications in remote sensing. Among them, one of the most common applications is spatial resolution enhancement through pansharpening. However, most traditional approaches rely on data from the same sensor. Besides, AI-based applications require a large amount of training data. These two limitations make such approaches non- suitable for precision agriculture applications, where a multi-sensor data fusion is needed and no training data is available. Moreover, such applications may require enhancing a particular mapping product without retrieving the complete spectral information. Thus, in this talk, we present a new approach for data fusion of RGB and spectral images for enhancing the spatial resolution of spectral mapping products relevant to agriculture applications, e.g., spectral unmixing, classification, and vegetation indices. Furthermore, unlike traditional methods, our approach allows fusing data from different sensors using a relatively simple neural network and internally derived training data.

[13] Conservation Agriculture Reduces Weed Infestation and Alters Weed Composition: Evidence from a Large-Scale Experiment

Mr. Gal Rozenberg -Technion - Israel Institute of Technology & ARO, Israel
Model Farm– Day 3

Weed control is a critical aspect of annual field crop management. Conventional irrigated agro-systems in Mediterranean regions are susceptible to soil degradation. Conservation agriculture can mitigate this and other adverse environmental impacts of conventional agriculture, particularly those resulting from prevalent weed control methods. This study examines the dynamics and the spatio-temporal aspect of weed in annual crops following the integration of two key practices of conservation agriculture: no-till and cover crops. Weed density, cover, community composition and spatial pattern were compared between conventional and conservation agriculture. Ten large experimental plots, five for each treatment, were surveyed for two consecutive years (2021 and 2022) in maize. Each year, weeds were intensively sampled twice: before- and two weeks after sowing the main crop. Individuals of every species were counted, and the total weed cover was estimated. Prior to sowing the main crop, weed density was significantly reduced in conservation agriculture plots in both years, though the effect on weed cover was inconsistent. After sowing the main crop, weed density and cover decreased in the conservation agriculture plots in the two years of the experiments. Weed composition and dominant species varied significantly between the two practices and sampling seasons. Furthermore, examining the spatial pattern of various weed species and overall community displayed varied levels of aggregation the spatio-temporal stability. This study demonstrates that conservation agriculture can provide a sustainable alternative to conventional weed control practices and provides practical information for weed management in conservation agriculture.

[14] Big Data, IoT, and AI Applications to Solve Agricultural Problems in the Southeastern USA: Three Case Studies

Prof. George Vellidis - University of Georgia, USA

Session D – Day 2

This presentation will focus on three different ways that big data, IoT, and AI applications are being used in the southeastern USA to solve important agricultural problems. The case studies are: using large meteorological data sets and IoT to power a smartphone-based irrigation scheduling tool for multiple crops that is also used to detect flash drought events for rainfed crops, using AI to predict the locations of aflatoxin hotspots in peanut fields, and using AI coupled with ground robots and spray-drones to detect disease and conduct prophylactic spot spraying.

[15] Exploring Data Collection Methods and Investigating the Emergence of Macrophomina Phaseolina in Cotton Fields: A Comprehensive Study in Agricultural Decision Support Systems

Prof. Gilad Ravid - Ben Gurion University of the Negev, Israel

Session E – Day 2

Recent advancements in agricultural decision support systems have greatly benefited from the integration of robust data collection methodologies. These methodologies can be broadly classified into two categories: obtrusive methods and unobtrusive methods. Obtrusive methods necessitate the active participation of the farmer in reporting plot-specific data, encompassing various levels of granularity. In this context, farmers are required to provide detailed information regarding their phenological stages, cultivation practices, such as crop varieties, fertilization regimes, pest and disease management strategies, yield outcomes, and more. On the other hand, unobtrusive data collection methods circumvent the need for direct involvement from the farmer. These methods leverage remote sensing technologies and other non-invasive sources to gather agricultural data. Remote sensing techniques, including satellite imagery, aerial surveys, and ground-based sensors, all offer valuable insights into crop health, environmental conditions, and spatial variations within the farming landscape. These unobtrusive approaches enable the collection of large-scale, temporally extensive datasets, which can capture broader trends, patterns, and environmental influences without imposing any additional burden on the farmers. By employing a combination of obtrusive and unobtrusive data collection methods, agricultural decision support systems can access a comprehensive array of information. The integration of farmer-reported data through obtrusive methods ensures the inclusion of context-specific details and firsthand expertise, enhancing the system's accuracy and applicability to individual farming contexts. Meanwhile, unobtrusive data collection methods contribute by providing a broader perspective, allowing for the identification of overarching trends and landscape-level insights.

These diverse data collection approaches empower agricultural decision support systems to make informed and effective recommendations. By leveraging the advantages offered by both obtrusive and unobtrusive methods, these systems can provide farmers with tailored and timely advice, enabling them to optimize their farming practices, enhance productivity, and mitigate potential risks. The integration of advanced data collection techniques represents a pivotal advancement in the field of agricultural decision support systems, ultimately fostering sustainable and efficient agricultural practices.

The current research analyses the different methods and their impact on agricultural practices and demonstrates few studies utilizing them. The study on the emergence of Macrophomina Phaseolina in cotton fields aims to provide a comprehensive understanding of its complex dynamics. Macrophomina Phaseolina, a notorious pathogen, poses a significant threat to Pime cotton yields on a global scale, making it imperative to investigate its impacts. To achieve this, a meticulous data collection process was employed, encompassing 500 plots over an extensive eight-year period, involving over 30 participants, ensuring the representation of various geographical locations and farming practices.

To gather the necessary information, a combination of obtrusive and unobtrusive data collection methods was employed. Obtrusive methods involved direct interactions with farmers, where detailed data related to phenological stages, cultivation practices, environmental conditions, disease incidence, and yield outcomes were collected. This approach allowed for the acquisition of in-depth knowledge about the specific conditions under which Macrophomina Phaseolina thrives and its subsequent impact on cotton yields. Additionally, unobtrusive data collection methods were used concurrently. These unobtrusive data sources enriched the dataset by capturing environmental variables that influence the emergence of Macrophomina Phaseolina. Machine learning techniques, particularly decision trees and Xgboost, were then employed to analyze the collected data. Through the application of these sophisticated algorithms, association rules and complex relationships among the measured variables were discovered. This analysis unveiled valuable insights into the emergence of Macrophomina Phaseolina and its intricate influences on cotton growth. By leveraging these findings, improved strategies and interfaces for cotton cultivation can be devised, enabling farmers to proactively manage and mitigate the impact of this pathogen. Overall, this study represents a comprehensive and interdisciplinary approach to understanding the emergence of Macrophomina Phaseolina in cotton fields. By combining obtrusive and unobtrusive data collection methods with advanced machine learning techniques, a rich and diverse dataset was established, providing a deeper understanding of the pathogen's dynamics. The insights gained from this research have the potential to inform agricultural practices and contribute to the development of more effective strategies for managing Macrophomina Phaseolina and optimizing cotton yields

[16] AI, Data Analytics and Precision Tools for Intelligent and Climate-Resilient Systems

Prof. Glen C. Rains - University of Georgia, USA

Session E – Day 2

Agricultural production has experienced tremendous gains in the last 100 years, leveraged by technological developments in crop and animal breeding, soil fertility, integrated pest management and irrigation. Though scientists continue to make incremental improvements in agricultural yields, the global population is expected to increase from the current 7.8 billion to 10 billion people by 2050 and there are daunting challenges to meeting our future food and fiber needs. A few of those issues include urbanization, climate change, extreme weather events, invasive species, loss of biodiversity, resistant weeds and insects, pollinator and soil health concerns, increased conflicting water demand, rural economic stability, labor shortages and supply chain disruptions. In particular, climate change has moved climate zones poleward thereby shifting plant, animal and disease ranges while increasing frequency and intensity of extreme weather events and climate variability. Subsequently, meeting the increasing demand for food and fiber is a complex problem that will require interdisciplinary cooperation and research to solve. Our team of scientists and engineers are working on several projects including: a lambda architecture in AI and data analytics to manage ETL of data at large scale for developing farm management schemes as well as supporting crop phenotyping and also developing IoT devices for pest and invasive species detection for rapid notification of pest movement while leaving the device untouched for up to two months. We are also assessing the techno-economic consequences of scalability of robotic systems and the use of AI and machine learning tools to create predictive models for in-season management of cotton production and the adoption of these tools across other crops. Intelligent multi-purpose rovers that can accept tool attachments for planting, scouting, pest management, and harvest are being developed for small to mid-sized farmers. These units can be scaled by number to the acreage of the farmer and used across multiple crops. Finally, we are investigating ways to improve farmer engagement in new agricultural technology through online and hands-on training that covers computer beginners to advanced precision management.

[17] Enhancement of Low-Cost Sensing Devices for Precision Agriculture

Dr. Iftach Klapp - Agricultural Research Organization, Volcani Institute, Israel

Session A – Day 1

Precision agriculture relies on sensing capabilities, which in turn increases the required sensory infrastructure in the field. While many agricultural scenarios require accurate data, the availability of such sensors suitable for work in field conditions is still limited, and their cost is still high. This talk explores a few cases our team studied in the past few years. We demonstrate a few barriers associated with system limitations while working in environmental conditions, where overcoming them relies on post-processing and machine learning of the outputs while using a machine learning approach and prior knowledge originating from the physical modeling of the sensor.

[18] Case Studies in Precision Livestock Agriculture; IoT, AI, and ML from Research, to Model Farms, towards Practical Farm Application

Prof. Ilan Halachmi - Agricultural Research Organization, Volcani Institute, Israel

Session B (Part 1) – Day 1

Not Available

[19] Networking and Computing Infrastructure for Large Scale Agricultural Testbeds Supporting the IoT4Ag Engineering Research Center

Prof. James Krogmeier - Purdue University, USA

Session B (Part 1) – Day 1

The goal of the NSF-funded IoT4Ag ERC is to sustainably ensure food, energy, and water security for future generations. To accomplish its mission, Center members focus on the development of low-cost sensor technologies to measure plant and environmental variables at various spatiotemporal scales, on communication technologies that connect sensor data to the cloud, and on data-driven models and control to allow farmers to close the loop of smart agricultural intervention. The ERC is also researching software and hardware platforms to create a data network to seamlessly connect researchers to instruments, computing, and control experiments across multiple universities and at large scale. In this talk we will describe the design of the data system and some ideas for a future network for autonomous agricultural sensing covering potentially thousands of hectares and dozens of university experimental research farms. This system design also enables interoperability at the event level (rather than the file level) which opens many pathways for innovation and connectedness along the entire ag value chain. The new network infrastructure could finally deliver on the large-scale data requirements of advanced machine learning and artificial intelligence for critical agricultural applications.

[20] NSF Investments in the Future of Precision Agriculture

Dr. Jason Hallstrom - National Science Foundation, USA

Session C (Part 1) – Day 1

Not Available

[21] A Digital Twin Framework for Precision Agriculture

Dr. Lizhi Wang - Iowa State University, USA

Session D – Day 2

We present a digital twin framework for plant breeding and crop growth analysis. This framework integrates plant physiology with artificial intelligence in order to create a digital representation of the plant breeding or crop growth process. We will present preliminary research results to demonstrate the effectiveness of the proposed framework in descriptive, predictive, and prescriptive analyses.

[22] Improving Fertigation Scheduling by Combining Continuous Monitoring and Numerical Modeling of the Root Zone

Prof. Naftali Lazarovitch -Ben-Gurion University of the Negev, Israel
Session D – Day 2

In recent years, tremendous progress has been made in making the information gathered by sensors located on agricultural fields available almost immediately; transferring the data directly to the cloud and rapidly presenting it to researchers, decision-makers, and farmers, assists in optimally determining the timing, amount, and composition of fertigation. There have been ongoing efforts to reduce the technological and economic barriers for the efficient and reliable use of sensors that continuously monitor the root system's heterogeneous and dynamic nature. Despite this, there are still many open questions related to determining the structure and installation locations of the sensors, the optimal algorithm with which the scheduling is determined, and the way in which different sensing methods are combined to make optimal decisions.

Sensor development is usually done using in situ experiments. These experiments are complex and expensive, and they ultimately result in a long development time. The use of numerical models may accelerate sensing method development and the selection of the optimal algorithm for fertigation. Numerical models are used as a research tool for understanding, quantifying, and predicting phenomena and processes in the soil-plant-atmosphere system and for planning and managing water resources and their quality, including irrigation, drainage, etc. Despite their complexity, the use of numerical models is increasing thanks to a better understanding of water flow and solute transport processes, the development and improvement of mathematical methods for solving equations, and the accelerated development of computers capable of calculating different processes simultaneously in small intervals of time and space.

The presentation will review three sensing methods and will present a combination of models that solve the water status and the fertilizer concentration in the root zone. The methods that will be reviewed are the following: a. a tensiometer for measuring the soil pressure head; b. a suction cup for inferring the soil solution concentration; and c. a minirhizotron for evaluating the root system structure. There is no doubt that determining optimal fertigation requires a multidisciplinary approach that considers the root zone's physical, chemical, and biological characteristics. The combination of continuous measurements and numerical models may improve decision-making regarding the application of resources, thus contributing to optimizing the use of water and fertilizers while increasing economic profit and reducing environmental impacts.

[23] Data-Driven Estimation of Actual Evapotranspiration to Support Irrigation Management: Testing Two Novel Methods based on an Unoccupied Aerial Vehicle and an Artificial Neural Network

Dr. Offer Rozenstein - Agricultural Research Organization, Volcani Institute, Israel

Session B (Part 2) – Day 1

Recent advances in remote sensing and machine learning show potential for improving irrigation use efficiency. In this study, two independent methods to determine the irrigation dose in processing tomatoes were calibrated, validated, and tested in an irrigation experiment. The first method used multispectral imagery acquired from an unoccupied aerial vehicle (UAV) to estimate the FAO-56 crop coefficient, Kc. The second method used an artificial neural network (ANN) trained on eddy covariance measurements of latent heat flux and meteorological variables from a nearby meteorological station. An irrigation experiment was conducted, where the farmer was instructed through a mobile application with updated irrigation recommendations. Evapotranspiration estimated by the new methods was set as the irrigation dose for the UAV and ANN treatments. The best-practice irrigation, commonly used by the regional farmers, was set as the control treatment (100%), guided by an irrigation expert and soil sensors for feedback. Derivatives of this treatment at 50%, 75%, and 125% of the control irrigation dose were tested. Yield, water use efficiency (WUE), and Brix level were measured and analyzed. Results show that both methods, UAV and ANN, estimated evapotranspiration to derive the irrigation dose at a near-perfect agreement with best-practice irrigation, both in the total amount and irrigation rate. Furthermore, there were no significant differences between the best practice and the experimental treatments in yield (117 ton/ha), water-use efficiency (31.7 kg/m3), and Brix (4.5°Bx). These results demonstrate the potential of advanced machine learning techniques and aerial remote sensing to quantify crop water requirements and support irrigation management.

[24] Modeling the Cost of Deficit Irrigation

Dr. Or Sperling - Agricultural Research Organization, Volcani Institute, Israel
Session C (Part 2) – Day 2

Optimal irrigation for almond trees requires surpassing current Israeli practices. Almond trees experience continuous stress, both chronic and acute. Traditional physiological measurements and individual field sensors are insufficient for effective irrigation management. To address this, predictive models that integrate multiple data layers can guide irrigation decisions. With comprehensive data records at our disposal, we can develop a more precise and data-driven approach to almond tree irrigation. By leveraging these insights, we can enhance almond tree health and productivity through improved irrigation strategies.

[25] Artificial Intelligence for Agricultural Sustainability

Prof. Raj Khosla - Kansas State University, USA

Session A – Day 1

Sustainable agriculture is an urgent global priority, and several ongoing efforts are underway to achieve this goal by benchmarking the USDA's innovation agenda. The primary objective is to increase US agricultural production by 40 percent while halving the environmental footprint of agriculture by 2050. Reduction of agricultural inputs has been a decadal focus of precision agricultural practices by quantifying spatial variability in soils and crops. However, with the increasing adoption of precision management techniques and practices, there is a growing interest in harnessing the power of data in making evidence-based management decisions. The success of future farming practices, including output, efficiency, and sustainability, would depend significantly on "*farming the data*". This presentation will share research-based examples on how precision agriculture is transforming crop production with information technologies and various aspects of big-data analytics, including machine learning (ML) and artificial intelligence (AI). It will showcase case studies where big-data and AI have been instrumental in addressing agronomic challenges and enhancing our understanding of variability in agricultural systems, leading to better decisions. The integration of big-data analytics and AI has the potential to drive the transformation of precision agriculture and contribute towards achieving sustainable agriculture.

[26] Early Sub-Soil Detection of Broomrape Infestation Using Spectral Data

Dr. Ran Lati - Agricultural Research Organization, Volcani Institute, Israel

Session C (Part 2) – Day 2

The obligate root parasitic weeds, commonly known as broomrape (*Orobanche* and *Phelipanche* spp.), cause severe damage for vegetable and field crops worldwide. The most effective method to control these parasites is herbicide application. Currently used herbicide-based management protocols rely on homogeneous application that ignores spatial variations within and between fields. It is thus likely that large amounts of herbicides are being used unnecessarily, and that targeting herbicide application exclusively to broomrape-infected areas would significantly reduce herbicide usage. Early broomrape detection can facilitate site-specific control of this weed, however, this task is challenging as most of its life-cycle takes place in the soil sub-surface and by the time that broomrape shoots emerge, the damage to the crop is irreversible. The objective of our research is to develop methodologies for early broomrape-parasitism detection for several crop plants. Our hypothesis is that infected plants can be detected by spectral data, although they remain non-symptomatic to the human eye. We aim to investigate the impact of broomrape parasitism on primary plant traits and consequently on the host leaves (sunflower, tomato, and carrot) spectra using high resolution hyperspectral imaging coupled with advanced machine learning algorithms. Then, we aim to study which spectral regions are most indicative, and to develop a drone-based multispectral remote sensing methodology for early detection of broomrape infected plants. Providing early and accurate maps of infected plants within the field is essential for decision support systems and for precise herbicide application, thus promoting the overall goal of site specific weed management and sustainable food production.

[27] Predicting Nitrogen Content in Citrus Orchards Canopy using UAV and Satellites Data

Prof. Raphael Linker -Technion - Israel Institute of Technology, Israel

Session E – Day 2

Nitrogen (N) is usually considered the most significant nutrient and the growth-limiting factor for commercial orchards. However, N fertilizers are often over-applied, which may cause a reduction of the yield crop, leading to financial losses and environmental damages. Hence, the accurate-as-possible nutrient status of the plants is required considering the spatiotemporal variation in the orchard. The canopy N concentration (CNC) is traditionally determined by chemical analysis of selected leaves. Remote sensing based on spectral sensors mounted on unmanned aerial vehicles (UAVs) and satellites has been proven to be an efficient method for CNC prediction. However, each of the platforms has its advantages and limitations. This work investigated the ability to combine Sentinel-2 data with UAV-data to derive improved estimates of canopy nitrogen content in citrus orchards. We developed a new framework to infer the nitrogen content in citrus-tree at the canopy level using spectral data, vegetation indices, and machine learning (ML). The framework includes four steps: (1) preprocessing the multi-spectral data acquired by UAV; (2) and preprocessing the Sentinel-2 data, (3) feature extraction, (4) data fusion for model calibration and validation based on ML techniques. Our main achievements have been (1) the development of a time-efficient procedure to delineate individual trees in the orchard and extract information from the tree scale based on segmentation models; (2) a ML model for CNC assessment, based on UAV spectral data and vegetable indexes (R^2=0.71, 10% error for the three-year model); and (3) adding Sentinel-2 spectral data into the model, followed by constructing a ML model to assess CNC at Sentinel-2's pixel scale (10 m^2), which resulted in R^2=0.76 and 8% error. The framework developed will reduce the need for chemical analyses of leaf tissue and enable much more efficient monitoring of CNC as well as estimation of its spatial and temporal variability in the orchard.

[28] Using Remote Sensing to Close the Yield Gap in Almond Orchards

Dr. Shahar Baram - Agricultural Research Organization, Volcani Institute, Israel

Session C (Part 2) – Day 2

Tree-crops such as almond orchards are incredibly complex. Consequently, the identification of key yield determinants may provide not only the ability to predict yield but also enhance the ability to manage within-field variability, minimizing the yield gap at the tree level (i.e., the difference between the yield potential and the actual yield). This work aims to investigate the environmental, biological, and management factors that determine the tree-level yield variability of almond orchards. The research is conducted at three neighboring plots in Kedma, Israel, consisting two cultivars Cochva 53 and Um-El Fachem. Thirty monitoring trees per cultivar were selected using a stratified random design. These trees are sampled monthly to determine the nitrogen (N) content in the leaves and the stem water potential (SWP), concomitantly to UAVs-based thermal, LiDAR, RGB, and multispectral imagery. The ground-collected data is used to train machine learning algorithms to predict the leaf-N content and SWP at the tree level in the orchards. Results from the first year of monitoring show very high spatial variability in all measured parameters and yield. At this stage, we are studying the correlations between the spatiotemporal variabilities in the measured parameters and the yield. For that, a large set of tree-based yield data is needed. The main key determining factors will be used to develop a spatial decision support system (SDSS) for irrigation and fertilization based on dynamic in-season site-specific management zones (MZs). Once completed, our research should breach the gap between fundamental science and farming applications by supporting decisions for optimizing almond yield.

[29] Harnessing Data Standards to Accelerate Collaborative Agronomic Big Data Research

Dr. Shai Sela - Agmatix, Israel

Session B (Part 1) – Day 1

The quantity and scope of agronomic data available for researchers in both industry and academia is increasing rapidly. Data sources include a myriad of different streams, such as field experiments, sensors, climatic data, socioeconomic data or remote sensing. The lack of standards and workflows frequently leads agronomic data to be fragmented and siloed, hampering collaboration efforts within research labs, university departments, or research institutes. Researchers and businesses therefore allocate significant time resources into unifying these fragmented data layers into a coherent structure. Implementing data standardization schemes can enable efficient collaboration, and leveraging the collective power of the research community to address critical agronomic knowledge gaps. This presentation will provide an overview of available research data standardization tools and explain the underlying FAIR and other data management principles. Using Agmatix's Axiom platform as an example, we will demonstrate how data from multiple sources can be standardized and used for insightful modeling. We have used 3774 experimental data points from multiple sources in the United States – universities, commercial associations and farm-management systems - to construct a corn prediction model (R^2 = 0.9. RMSE = 1.0 Mg/Ha). The standardization platform unifies all datasets to common headers and units, allowing exploration of data distributions to ensure an adequate crop yield parameter space is covered. While demonstrated here on corn yield, many different agronomic research domains can benefit from standardization of data. We call on the agronomic research community to adopt standardization, boost collaboration efforts, and increase the potential for tackling the current global agronomic challenges.

[30] The Potential of Remote Sensing of Cover Crops to Benefit Sustainable and Preciion Fertilization

Mr. Simon Futerman - Hebrew University of Jerusalem and ARO, Israel

Model Farm – Day 3

Not Available

[31] Operationalizing Precision Sustainable Agriculture

Prof. Steven Mirsky - United States Department of Agriculture, USA

Session A – Day 1

The Precision Sustainable Agriculture team is enabling climate smart farming by equipping farmers with the knowledge and tools to be more site-specific, regenerative, and adaptive. This transdisciplinary team builds the cyberinfrastructure and community of practice necessary for deploying the latest in computer vision and sensing technologies to capture the complexity of climate, soil, and management interactions and standardize data collection across 26+ states and hundreds of farmers' fields. Data collected from these on-farm and on-station research networks are used to build technology transfer pathways that operationalize climate smart practices for farmers through technology and web-based decision support tools farmers use for real-time decision making and long-term planning.

[32] Predicting In-Season Soil Mineral Nitrogen in Corn Production Using Generative Deep Learning Model

Prof. Taejoon Kim - University of Kansas, USA

Session B (Part 2) – Day 1

One of the biggest challenges in nutrient management in corn (Zea mays) production is determining the amount of plant-available nitrogen (N) that will be supplied to the crop by the soil. Measuring a soil's N-supplying power is quite difficult and approximations are often used in lieu of intensive soil testing. This can lead to under/over-fertilization of crops, and in turn, increases the risk of crop N-deficiencies or environmental degradation. In this paper, we propose a deep learning model to predict the inorganic-N content of the soil on a given day of the growing season. Since the historic data for inorganic nitrogen (IN) is scarce, deep learning has not yet been implemented in predicting soil nitrogen content. To overcome this hurdle, Generative Adversarial Network (GAN) is used to produce synthetic IN data and is trained using offline simulation data from the Decision Support System for Agrotechnology Transfer (DSSAT). Additionally, the time-series prediction problem is solved using long-short-term memory (LSTM) neural networks. This model proves to be economical as it gives an estimate without the need for comprehensive soil testing, overcomes the issue of limited available data, and the accuracy makes it reliable for use.

[33] A Machine Learning and Geoinformatics Water Erosion Approach in Agricultural Catchments

Prof. Tal Svoray - Ben Gurion University of the Negev, Israel

Session B (Part 2) –Day 1

The study of water erosion in agricultural catchments is crucial for maintaining sustainable land-use practices and mitigating the negative impacts of soil erosion on the environment. Machine learning tools have recently emerged as a promising approach for quantifying erosion risk and soil health, as they can effectively analyze large amounts of spatio-temporal data and identify patterns that may not be visible through traditional statistical techniques. In this study, we apply machine learning algorithms to assess erosion risk and soil health in agricultural catchments. We use a range of environmental variables, such as soil type, land use, cultivation method, slope gradient, and rainfall intensity, to train and test models that predict areas with a higher probability of soil erosion. The analysis includes data from a supersite in the center of Israel. The results show that machine learning algorithms can accurately predict erosion risk in agricultural catchments, with high precision and recall rates. The variables that had the highest predictive power were cultivation method, rainfall intensity, and hillslope decline. Moreover, our analysis identified specific areas that are particularly vulnerable to water erosion, which could help guide land-use decisions and management practices. Overall, this study demonstrates the potential of machine learning tools for studying erosion risk in agricultural catchments, providing valuable insights for land managers and policymakers seeking to ensure sustainable land-use practices.

[34] Advances in Sensing Applications for Agricultural Unmanned Aerial Vehicles (UAVs)

Dr. Tarin Paz-Kagan - Ben Gurion University of the Negev, Israel

Session C (Part 2) – Day 2

In recent years, the use of UAV platforms in the agricultural sector has increased dramatically. Integrated with sensors, UAVs enable more frequent and faster data acquisition, making them more valuable for monitoring farming systems than traditional agronomic methods or remote sensing platforms. The procedure involves sensing, recording, processing, and analyzing data from various sensors on UAV platforms. The use of UAVs in precision agriculture (PA) has steadily increased since the beginning of the twenty-first century. According to estimates, the industry market for UAVs is approximately $127 billion, with the agricultural UAV sector accounting for $32.4 billion, representing 25% of the global UAV market. To comprehensively review UAV-RS applications in PA, we formulated the following questions: What are the available UAV sensors for PA applications? How should one select the best UAV platform for different PA tasks? What needs to be considered in flight planning and performing necessary pre-processing to obtain high data quality? What are the main applications of UAV-RS in PA? Finally, we will discuss future applications and challenges, emphasizing multiple studies conducted to assess precision irrigation and fertilization, precision weed management, phenotyping, growth vigor, and yield assessment. Although UAVs have yet to be fully established in precision agriculture practices, they are starting to play an increasingly important role, assisting farmers with real-time monitoring and management strategies for more efficient and sustainable agricultural practices. The current lecture presents an overview of the advantages and limitations of UAV-RS platforms and their applications in PA and addresses future research applications and trends.

[35] Reforming Crops' Mineral Diagnostics by Chemometrics to Sustenance the Empirical Requirements of Decision Support Tools in Farming

Prof. Uri Yermiyahu - Agricultural Research Organization, Volcani Institute, Israel

Session C (Part 1) – Day 1

World farming requires precision fertilization to eliminate contaminations, improve crops' productivity, and ensure sustainability. Yet, chemical mineral analyses are overly expensive and labor-intensive to substantiate large datasets of plants' nutritional status, rendering farming to rely on discrete measurements for fertilization updates. Hence, we set out to restructure nutritional diagnostics in agriculture. First, we developed a unique experimental setup to produce a wide range of mineral concentrations in multiple crops. Then, we turned to analytical tools in alternative industries, mainly NIR and X-ray fluorescence used by the mining and pharmaceutical industries for mineral analyses. Finally, we integrated an array of statistical tools to adjust chemometric tools to the mineral matrices in various plant tissues. The novel chemometric projections fitted chemical analyses of macro and micro-elements' concentrations in multiple crops (e.g., vine, tomato, almond, citrus, and avocado leaves). The error range was ±5% of laboratory analyses (corresponding to common variability between laboratory assays), and repetitions were redundant. Moreover, it is a rapid analysis, and its procurement costs are significantly lower than current laboratory practices. We recently extended our efforts to the extension and commercial sectors, supporting field laboratories in India and Israel. Now, we are set to survey numerous crops throughout all their phenological stages at various growth conditions and produce the large datasets required for modern decision-support algorithms to guide farming.

[36] Integration of Artificial Intelligence and Sensing for Precision Farming

Dr. Victor Alchanatis - Agricultural Research Organization, Volcani Institute, Israel
Session A – Day 1

Modern agriculture is increasingly based on technology, both for monitoring and making management decisions, and for carrying out the operations in the field. Sensors' data become essential for monitoring the status and the needs of the crops, while their volume and complexity increase constantly. On the other hand, advances in artificial intelligence provide tools that can potentially extract meaningful knowledge from large volumes of data. Integration of the two fields may reveal new insights for better and more efficient management of resources following the principle of precision farming. The opportunities and the limitations of integrating artificial intelligence with sensing data will be explored.

[37] Specialty Crop Production using Artificial Intelligence in Florida, USA

Prof. Won Suk Lee - University of Florida, USA
Session C (Part 2) – Day 2

Specialty crops include fruits and vegetables, tree nuts, dried fruits, and horticulture and nursery crops. This talk will present various sensing systems using artificial intelligence for specialty crop production in Florida. Topics include mature and immature green citrus fruit detection for yield mapping, strawberry fruit and flower detection for yield forecasting, smartphone-based two-spotted spider mite detection, and strawberry plant wetness detection system.

[38] GeoEDF: A Framework for Designing and Executing Reproducible Geospatial Research Workflows in Science Gateways

Dr. X. Carol Song - Purdue University, USA

Session C (Part 1) – Day 1

Scientists in geospatial data-driven fields often spend significant efforts in “wrangling data”, i.e., accessing and processing data to make them usable in modeling and analysis tools. This NSF CSSI project has created GeoEDF, an extensible geospatial data framework, to reduce this barrier by creating seamless connections among platforms, data and tools, making large, distributed geospatial datasets directly usable in models and tools. Through an extensible set of community contributed, modular and reusable data connectors and processors, GeoEDF abstracts away the complexity of acquiring and utilizing remote datasets. Researchers can string them together into a workflow for execution in various environments including a well-established science gateway MyGeoHub, JupyterHub-based deployments, and as a Docker container on laptops. Initially focused on generally applicable geospatial data functions, domain-specific models and analysis, including ML model training and model ensemble, are being added. In this talk, we will provide an overview of GeoEDF and describe how it has been used and integrated in the larger cyberinfrastructure ecosystem to support and accelerate data-driven research and enable reproducible workflows.

[39] AgRobotics in the Era of IoT & AI for Sustainable PA

Prof. Yael Edan - Ben Gurion University of the Negev, Israel

Session B (Part 2) – Day 1

Commercial agricultural robots are available for many agricultural applications such as transplanting, cultivating, spraying, trimming and selective harvesting, and more are expected to appear in the next years as technologies such as machine vision and dexterous grasping become more capable and cost effective. By equipping these robots with advanced sensor technologies, real-time accurate and timely crop data can be collected providing improved spatial and temporal crop monitoring and management. With the advent of IoT (internet of things) and cloud computing, AI (artificial intelligence) systems can then integrate the online sensory information with remote sensing data, historical data, Information Communication Technologies (ICT) [e.g., cellular technology, global positioning system (GPS), geographic information systems (GIS)], and biological knowledge of the crop and its environment (e.g., crop weed and pest growth models, weather models). AI models developed for the different crop growth phases: cultivation (e.g., selecting crops to be planted, planning and preparation of land, irrigation planning, seed preparation, seed sowing), monitoring and controlling the growth (crop health monitoring, fertilizer use and application, disease/weed identification, and pesticide spraying), and harvesting (e.g., crop cutting, storing, and selling to the market) can be linked to the robots operating in the field. Farmer feedback can be incorporated 'on-the-go' to enable continuous improvement of decisions and develop a ‘green thumb’ for the robots. These intelligent systems can also include social, environmental and economic parameters to optimize decisions. The AI system output can then provide on-the-go controls for the smart farm robot to apply the optimal precision technology at the optimal time and the optimal location (e.g., water and fertilization application, harvesting timing, disease/pest management) leading to improved production costs, yield and quality and enabling better crop control and management.

The development of autonomous robots in agriculture will enable us to provide the operational smart farming solutions. Current Digital Farming (also known as Agriculture 4.0) enabled by precision agriculture aims to optimize the agricultural processes by adapting the operations to apply what is needed, when and where is needed. Although information is provided at the plant, crop, soil and environmental level, overall control is mostly at the field level only (not enabling individual plant treatments). Farmers are overwhelmed with data, what is currently missing is the closed loop control which can be provided by the robots. The overall concept referred to as Agriculture 5.0, will empower these data-driven farms linking the sensors, IoT and AI to robots that can provide ultrahigh-precision farming (providing ‘phytotechnology’=precise decisions related to how, where and when at the plant level). The concepts of multi-robots, human-robot collaboration, and environment reconstruction from aerial images and ground-based sensors and robots working together will advance smart farming ensuring sustainable precision agriculture.

[40] Introduction to the Model Farm for Sustainable Agriculture, Newe Ya'ar, Volcani Institute

Dr. Yael Laor - Agricultural Research Organization, Volcani Institute, Israel

Session C (Part 1)– Day 1

The Model Farm for Sustainable Agriculture was established five years ago in Newe Ya'ar, the northern campus of Volcani Institute (https://www.modelfarm-aro.org/?lang=en). This is a pioneer mega project, aimed at studying, demonstrating, and implementing sustainable agricultural practices. We built a full-scale real connection between research and practice of sustainable agriculture. Our five key principles are (1) Reducing external inputs; pesticides, fertilizers, water, and energy. (2) Recycling all organic wastes; "zero waste”. (3) Conserving the soil. (4) Designing an ecosystem that sustains and supports agriculture, biodiversity, and local habitats, and (5) Increasing animal welfare. With those key principles, we still should demonstrate sustainable economic revenue to farmers over the long-term. We recruited parts of the Newe Ya’ar farmland (150 ha) and cattle (200 heads) and translated our 'big ideas' into 5 main platforms (i) Almond orchard (ii) Field crops (iii) A buffer strip along the upper section of Nahalal River (iv) Ruminant Care & Feeding housing, and (v) Waste recycling. The almond orchard is divided into subunits: One is designed to study weed management and service (cover) crops, to minimize soil erosion and reduce herbicides use, a second includes wasp resistant cultivars, to reduce pesticides use, and a third includes drought tolerant cultivars, to cope with climate changes. The platform of the field crops is also divided into subunits. One is for alternative forage crops, a second is to practice service crops and organic additives, and the third is for precision agriculture practices. The buffer strip embeds research into a full river restoration program. The new ruminant housing (under work) is thoughtfully designed to improve animal welfare, production and profitability, and the waste recycling 'park' is equipped with a full-scale composting drum, demo-scale wetland, and lab-scale hydrothermal processing and composting simulations. The Model Farm has been equipped with state-of-the-art agricultural machinery as well as drones equipped with RGB, multispectral, thermal and LIDAR sensing. We are not an organic farm, neither 'pure' regenerative. We operate in light of the perception that the chances of achieving sustainability depend on the development and assimilation of technological innovation alongside a holistic view and re-adoption of traditional approaches.

[41] Towards Informed Postharvest Logistic Management Systems to Reduce Food Loss, and Other Challenges

Dr. Yael Salzer - Agricultural Research Organization, Volcani Institute, Israel

Session B – Day 1

Food loss poses a significant challenge for modern society. It jeopardizes food security and availability and leads to unnecessary wastage of resources. Abruptly, 45% of all fruits and vegetables are wasted along the food supply chain, about 6% - 37% during storage. Typically, postharvest storage management applies a First In, First Out (FIFO) logistics strategy that does not consider the product's prospective shelf life. The ability to predict future fruit quality is likely to support a more efficient First Expired First Out (FEFO) strategy and reduce food loss. To that end, in a series of studies, we conduct a large-scale, high-throughput phenotyping analysis of the effects of various pre-harvest and postharvest features on the quality of citrus and grapes. The large-scale datasets provided the basis for developing quality-prediction models targeted for future FEFO logistic management systems.

[42] Big data in Area-Wide and In-Field Scales

Dr. Yafit Cohen - Agricultural Research Organization, Volcani Institute, Israel

Session A – Day 1

Our research group leads studies in agriculture that utilize data-driven approaches for different spatial and temporal scales to support decisions in irrigation, fertilization and pest-management. In a long-term study, we developed advanced methodologies to exploit thermal imaging for water status mapping in various crops and scales (from single-leaves to commercial fields), and for their utilization in precision irrigation application. Throughout the years of research, vast thermal and multi-spectral images along with other sizeable soil and plant measurements were accumulated and our understanding of the capabilities and limitations of thermal imagery in the context of precision irrigation have become more and more established. A major limitation in this context is the unstable relationships (in space and in time) between thermal-based indices and plant water status. It seems that this is one of the limitations holding back the commercial assimilation of this technology. Integrating databases from different parts of the world and using ML techniques may deepen our understanding of the factors for the instability and thus to solutions. In the last few years, we started to explore a new way to map soil nitrogen and phosphorous availability by remote-sensing in the VIS-NIR range of cover crops preceding the cash crop. This approach is a link in the chain of integrating conservation agriculture and precision agriculture practices.

In parallel to our data-driven studies for in-field scales (precision ag), we utilized the ecoinformatics approach (the use of long term and large scale observational data) to improve the sensitivity of time-series satellite images for early detection of water-stress in crops and to improve (uniform) irrigation decisions in the field scale. Similarly, we utilized the ecoinformatics approach to study various pest dynamics and to advance area-wide pest management. By harnessing growers associations and by developing and using automatic monitoring traps, extensive databases were assembled to characterize Medfly dynamics. This in turn, paved paths for synchronizing pest management and for improving insecticide usage efficiency. In order to realize and enhance the application of insights derived from the different data-driven research approaches it is necessary to combine forces in data collection and data analysis by different research groups in the world.

[43] AI-Enhanced Technologies for Precision Management of Specialty Crops

Dr. Yiannis Ampatzidis - University of Florida, USA

Session E – Day 2

This talk presents AI-enhanced emerging technologies for precision agriculture applications and Best Management Practices (BMPs). It describes how artificial intelligence, automation, and robotics can be used to enhance the precision management of resourses and address climate change issues. Examples of emerging technologies presented here include smart and variable rate sprayers for pest and disease management, and UAVs for precision nutrient and pest/disease management (among others). These emerging tools and technologies can enhance the sustainability of commercial crop production and the competitiveness of the agricultural industry. These novel technologies can reform farm production to a more sustainable and climate-resilience agriculture.

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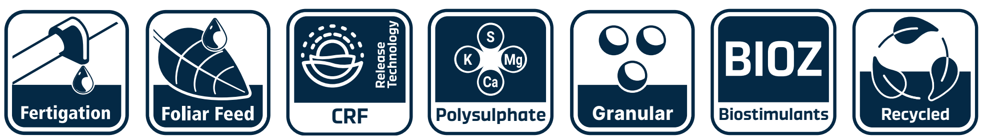

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