



## ABC Robotics MOST Workshop Program

Alon Building for Hi-Tech, Building 37, room 202			
9:00-9:30	Registration & refreshments		
9:30-10:00	Greetings - <b>Prof. Dan Blumberg</b> , Vice President for Regional and Industrial Development. Opening remarks - <b>Dr. Ami Appelbaum</b> , Chief Scientist and Chairman of the Israel Innovation Authority		
10:00-10:30	KEYNOTE SPEAKER: <b>Prof. Oliver Korn</b> , Offenburg University <b>Cultural Differences in Social Robot Acceptance.</b> A Case Study and a Concept for Future Field Research		
10:30-11:00	<b>Prof. Yael Edan</b> - Pitch on MOST workshop sessions		
<b>The workshop will split to 2 groups</b>			
	<table border="1" style="width: 100%;"> <tr> <td style="width: 50%; text-align: center;"><b>Alon Building for Hi-Tech, Building 37, room 202</b></td> <td style="width: 50%; text-align: center;"><b>Ilse Katz Institute for Nanoscale Science and Technology, Building 51, room 015</b></td> </tr> </table>	<b>Alon Building for Hi-Tech, Building 37, room 202</b>	<b>Ilse Katz Institute for Nanoscale Science and Technology, Building 51, room 015</b>
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11:15-12:15	<b>Session 1</b>		
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12:15-13:45	Lunch break & poster session - lobby building 37		
13:45-14:15	Industry speaker - <b>Reuven Della-Torre</b> , Co-Founder & CTO at Caja Robotics Alon Building for Hi-Tech, <b>Building 37, room 202</b>		
14:30-15:30	<b>Session 2</b>		
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15:30-15:45	Coffee break		
15:45-16:45	<b>Session 3</b>		
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## ABC Robotics MOST Workshop Detailed Sessions

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	The Autonomous Operating System — Infrastructure for Autonomous Systems	Ronen Brafman	Laser tissue soldering of the gastrointestinal tract	Uri Netz
	Realizing the AOS Vision	Or Wertime Ronen Brafman	Robot assisted laser tissue soldering Machine Vision for Robot Assisted Laser Tissue Soldering	Max Platkov Maya Chuchem
14:30-15:30	<b>Session 2</b>			
	<b>Bridging the Gulfs: Robotic design for acceptable and expectable social assistive robots (SARs)</b> Prof. Tal Oron-Gilad, Prof. Yael Edan, Industrial Engineering & Management; Dr. Nea Ehrlich, Arts		<b>Novel Minimally Actuated Snake-Like Robot for Industrial, Medical, Agricultural, Space and Search &amp; Rescue Applications</b> Dr. David Zarrouk, Mechanical Engineering	
	Towards design of SARs for the elderly; incorporating participatory design tools.	Adi Bulgaro, Ela Liberman-Pincu, Tal Oron-Gilad	Minimally actuated serial robot: design and path planning	Yotam Ayalon David Zarrouk
	Judging a socially assistive robot (SAR) by its cover: The effect of SARs' visual qualities (VQs) on users' perceptions and attitude.	Ela Liberman-Pincu Tal Oron-Gilad	Path planning of a minimally actuated serial robot using A* algorithm	Yanai Gal David Zarrouk
	Usefulness and Otherness in Robotic Artworks: The Potential of Art as Practice-Based Research for SARs	Nea Ehrlich	Minimally actuated continuous track robot	Tal Kislassi David Zarrouk
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	Technology domestication in later life	Galit Nimrod Yael Edan	A visual-acoustic perception apparatus for robotic nanostructure application in vineyards	Edo Moran-Wexler Sigal Berman
	"Gymmy:" Designing and testing a robot for physical and cognitive training of older adults	Maya Krakovski, Shikhar Kumar, Shai Givati, Moshe Bardea, Oded Zafrani, Galit Nimrod, Simona Bar-Haim, Yael Edan	Optimal manipulator characterization for selective spraying of nano materials in vineyards	Roni Azriel Avital Bechar
Between fear and trust: older adults' evaluation of socially assistive robots	Oded Zafrani, Galit Nimrod, Yael Edan	Learning spraying profiles for robotic nanostructure application in vineyards	Omer Dadon Sigal Berman	





## BGU Agricultural Biological Cognitive MOST Workshop November 24, 2021, Book of Abstracts

### Cultural Differences in Social Robot Acceptance. A Case Study and a Concept for Future Field Research

**Prof. Oliver Korn, Offenburg University**

This talk discusses recent findings on cultural differences affecting the acceptance and design preferences of social robots. Based on a survey with 794 participants from Germany and three Arab countries, we investigate how culture influences the preferences for certain robotic attributes. We look at social roles, abilities and appearance, emotional awareness and interactivity of social robots. We found that preferences do not only differ across cultures, but also within countries with similar cultural backgrounds. This gives rise to an interesting field of applied research in a collaboration between Germany and Israel, as both countries are technologically and economically advanced but have different traditions and ideas about the role of technology. We outline potential future research, examining how German and Israeli users interact, or avoid interaction, with robots within specific contexts of use.

**OLIVER KORN** is a full professor for Human Computer Interaction (HCI) and director of the Affective & Cognitive Institute (ACI) at Offenburg University in Germany. He also is a certified Project Manager (German Chamber of Commerce), Senior Member of ACM and Professional Member of the IEEE. His main areas of research are context-aware assistive systems, affective computing, and robotics. In the ACI, he bundles these fields with an interdisciplinary research team. The overall vision is to enrich environments by intuitive interfaces, smart context-aware systems and playful applications, which adapt to both the users and the context.

Since 2001, he works on HCI projects – amongst others at the Fraunhofer Institute for Industrial Engineering (IAO), the KIT (Karlsruhe Institute for Technology), and the University of Stuttgart. There, at the Institute for Visualization and Interactive Systems within the SimTech Excellence Cluster, he obtained his PhD in Computer Science. In 2004, he co-founded the company KORION, a Fraunhofer spin-off. He oversaw over ten research projects for the European Commission and the German ministries of Research and Economy. His research is published in numerous publications, e.g. for ACM CHI, ASSETS, EICS, PETRA. He is member of several program committees and chaired ACM PETRA from 2018 to 2020. He edited the Springer books Game Dynamics (2017) and Social Robots (2019).

Indeed, social robots are a major research area he covers not only in research: as a “third mission project” research findings are communicated to the general public in a comic which can be viewed at <https://affective-lab.org/comics/>

<https://affective-lab.org/>





## AOS: An Autonomous Operating System for Robotics

### The Autonomous Operating System - Infrastructure for Autonomous Systems Prof. Ronen Brafman, Computer Science Department

Programming an autonomous robot is a challenging task that few engineers are capable of. It requires understanding the capabilities of software developed by diverse groups coming from different disciplines for navigation, manipulation, and object recognition, combining techniques in control theory, AI, and machine learning. Each specific application requires writing dedicated scripts that combine these different skills appropriately for achieving the task. When writing these scripts, programmers must also be aware of potential faults and recognize anomalous behavior in order to ensure successful task completion as well as safety. In this talk I will review the AOS vision. The autonomous operating system seeks to address these issues in order to considerably reduce the effort and knowledge needed to program autonomous robots. The AOS combines ideas from AI planning, knowledge representation, reinforcement learning, and anomaly detection algorithms to automatically carry out many of the steps required for programming autonomous robots.

### Realizing the AOS Vision Or Wertime, Computer Science Department

The AOS vision involves multiple interdependent components, covering planning, execution, user requirement modeling, execution monitoring, and learning. Building a usable system that provides this functionality and delivers on its promise of being usable by non-experts is a major software engineering and algorithmic challenge that involves many design decisions. In this talk I will discuss the systems' architecture, and various design decisions we made. To maximize productivity and supply a valuable growing system along the way, we decided to realize the AOS vision in an agile programming way with continuous deployment and integration % rather than using the waterfall model and design a complete system. Starting with its core element that supports automated planning and execution. Existing planning systems require significant integration efforts, may be tightly bound to a specific framework (ROS), and often do not support partial observability and probabilistic planning, which are fundamental for robotics. **The AOS system, on the other hand, is user-focused**, so the **user should only** supply his documented code in a particular structured format, called a PLP, a description of the environment and goals; all of the integration and robot operation is automatically done by the AOS. %The AOS has a modular design with a decision, unifying, and the functional layer; only the unifying layer cannot be replaced. Our current implementation includes a POMDP solver (decision) and a ROS middleware component (functional). However, our design already takes into account future components such as monitoring, model learning, and anomaly detection.





## Robot-assisted laser tissue soldering system

**Laser tissue soldering of the gastrointestinal tract, Nadav Agam<sup>1</sup>, Ido Ashbell<sup>1</sup>, Abraham Katzir<sup>2</sup>, Svetlana Basov<sup>3</sup>, Max Platkov<sup>3</sup>, Itzhak Avital<sup>1,4,5</sup>, Ilana Nisky<sup>6</sup> Uri Netz<sup>1,4</sup>.**

Anastomotic leaks following gastrointestinal tumor resections, bariatric surgery, trauma surgery and others are a major source of concern for clinicians and patients alike. These leaks can lead to increased rates of morbidity and mortality, extension of hospitalization, as well as a significant financial burden. Current conventional bonding methods in the gastrointestinal tract such as sutures/staples are far from perfect. Laser Tissue Soldering (LTS) is a tissue bonding technique, in which a laser is used to heat a proteinaceous component (solder) that creates a bond between tissues. LTS of the gastrointestinal system has the potential to overcome some of the disadvantages of sutures or staples and achieve a strong waterproof anastomosis with a possible reduction in anastomotic leak rates. Technological advances such as laser temperature control systems, robotic surgery, and others, have made the reproducibility and reliability of LTS achievable. We provide an up-to-date comprehensive review of the research in the field of LTS in the gastrointestinal tract and conclude principles for study design, outcome evaluation and integration of this technology.

### Robot-Assisted Laser Tissue Soldering, Dr. Max Platkov

Rapid, precise and reliable incision closure is a critical practice in many surgical procedures. Various solutions have been developed over the years, e.g. sutures, clips, adhesives or even laser-based closure. However, with the advantages they brought they all presented severe challenges. The laser soldering methods present a promising alternative, but this alternative presents challenges. In our experiments we heated a spot on the incision by a laser beam manually, and the beam moved along the incision length. We changed the soldering temperature of the spot and the time duration of heating the spot by the type and shape of the tissue to be closed. All these requirements depended on the skill and experience of the surgeon. This reduced the reproducibility and success rate of the method and led us to carry out further research and development.

We are developing now a system that makes use of the laser soldering system mentioned above and a robotic arm which moves the laser beam along the incision. This causes a computer program to control the power applied at each spot, and move the laser beam along the incision at a given rate, both of which determined the temperature of each individually illuminated spot, on the sample. We have constructed several prototypes for different types of samples. We changed the type of laser and solder used in each case. It is known that for various wavelengths the penetration depths of the laser beam inside the tissue are different. The bonding strength in each case is different, and we are trying to find the optimal conditions for closing incisions. When this is done we will try to find the optimal condition for moving the laser beam along the incision using the robotic system. This will include, as mentioned, the temperature of each heated spot and the heating rate. Our tissues were mouse skins and porcine bowels, tissues widely different in terms of their properties and the type of laser soldering procedure needed. This presentation will discuss our results so far, and the outlooks to the future of our work.

<sup>1</sup> Faculty of Health Sciences, Ben Gurion University, Beer-Sheva, Israel

<sup>2</sup> School of Physics & Astronomy, Tel Aviv University, Tel Aviv, Israel

<sup>3</sup> Department of Biomedical Engineering, Tel Aviv University, Tel Aviv, Israel

<sup>4</sup> Department of Surgery A, Soroka University Medical Center, Beer-Sheva, Israel

<sup>5</sup> Legacy-Heritage Oncology Center, Larry Norton Institute, Soroka University Medical Center, Beer-Sheva, Israel

<sup>6</sup> Department of Biomedical Engineering, Ben-Gurion University of the Negev, Beer-Sheva, Israel





## **Machine Vision for Robot Assisted Laser Tissue Soldering** **Maya Chuchem, Biomedical Engineering**

In this project, we are developing and validating a novel Robot-assisted Laser Tissue Soldering (RLTS) system that consists of an optical device - a fiber-optic diode-laser that heats the incision under temperature control, a robotic system that accurately maneuvers the distal tip of the fiber in teleoperated, shared and automatic control modes.

Machine vision has the potential to provide, both the robotic control, and the surgeon, guidance toward the optimal suturing path, using the visual information in the existing stereo video data. The path planning algorithm uses the double-camera video information as input and outputs the optimal path in 3d coordinates. It could warn when the conditions for soldering are not met and be used for autonomous soldering or for assistance.

Our approach is to make use of existing suturing data in order to train a module capable of tracking suturing task and direct it's visual attention to areas where soldering should be performed. The sub modules include a surgical needle detector, a suturing task classifier, and a heatmap to be used as a visual attention mechanism.

For tracking the needle itself we use the DeepLabCut [1] api to create CNN classifiers of needle parts in minimal invasive surgical video data. For suturing task classification we used the open access SurgicalAction160 [2] dataset as a toy model for a proof-of-concept clustering result which classifies the suturing action based on the kinematics of the needle. The visual attention heatmap is created using gaussians decaying in time, which allow integrating the temporal information with spacial position of the needle parts.

[1] Mathis, A., Mamidanna, P., Cury, K.M. *et al.* DeepLabCut: markerless pose estimation of user-defined body parts with deep learning. *Nat Neurosci* **21**, 1281–1289 (2018).

[2] Schoeffmann, K., Husslein, H., Kletz, S., Petschamig, S., Muenzer, B., Beecks, C. Video retrieval in laparoscopic video recordings with dynamic content descriptors. *Multimedia Tools and Applications* (2017).





## **Bridging the Gulfs: Robotic design for acceptable and expectable social assistive robots (SARs)**

### **Judging a socially assistive robot (SAR) by its cover:**

#### **The effect of SARs' visual qualities (VQs) on users' perceptions and attitude**

**Ela Liberman-Pincu, Tal Oron-Gilad, Industrial Engineering and Management**

We argue that the nature of the human-SAR relationship changes by the context of use and interaction level. Therefore, context and interaction must be incorporated into the design requirements. To align the robotic visual qualities (VQ) with users' expectations, we propose two human-SAR relationship models: context-based model- Situational based model and interaction-based model- Dynamic based model. Together with the VQ's evaluation, these models aim to guide designers in the design process of new SARs. Previous studies contributed to the understanding of users' perceptions and preferences regarding existing commercially available SARs. Yet, very few studies regarding SARs' appearance used designated SAR designs, and even fewer evaluate isolated visual features. In this work, we aim to assess the effect of isolated VQs systematically. To achieve this, we deconstructed the VQs attributes of SARs. Then, utilizing a taxonomy of visual qualities, we aim to reconstruct robots to their designated purposes and users. An exploration of how this is applied to domestic robots demonstrates body structure, outline, and color scheme. Thirty new SAR models that differ in their VQs were formed, allowing us to isolate characters one at a time. We used these designs to evaluate the perceptions and preferences of users and designers in three empirical studies. Together with the relationship models, the outcomes exemplify how to form guidelines for the industrial design processes of new SARs to match user expectations.

### **Towards design of SARs for the elderly; incorporating participatory design tools**

**Adi Bulgaro, Ela Liberman-Pincu, Tal Oron-Gilad, Industrial Engineering and Management**

Human-robot interaction of older people with robots is increasing. Future robots should complement or partially replace the caregiver workforce, which is growing significantly due to the aging population of the world. Solutions are necessary to help the elderly, especially considering Covid-19 (need for social distancing) and the anticipated shortage in caregivers for the elderly. However, assimilation of assistive robots into the population is not yet wide and many robot systems available now are not fit for eldercare. One of the ways to make robots that can support older adults maintain their independence is to use participatory design techniques to identify the essential characteristics and use cases of the robots. Participatory design is an approach that involves the user in the design process even before the robot exists. The inclusion of older adults in the design process is iterative, aiming that at the end of the design process, effective results will be achieved in designing robots that fulfill the needs and expectations of the elderly. In this research, we would like to create the mechanism through which it is possible to perform user-centered design along with the designers aiming to better integrate robots among the elderly in the future.





## **Usefulness and Otherness in Robotic Artworks:**

### **The Potential of Art as Practice-Based Research for SARs**

**Nea Ehrlich, Department of Arts, BGU**

As the field of robotics advances we are sure to see human-robot interactions proliferate, which explains the importance of researching social robotics through multiple perspectives. This multidisciplinary project explores the connection between robotic research, design and the arts. Robots and Art may seem like an unlikely symbiosis so it is vital to clarify the following: What is it about art and design that make it a useful contribution to this field?

The presentation focuses on robotic artworks of recent decades, incorporating both visual and HRI design, and explores the potentials of robotic artworks as practice-based research. Design has a central role to play in this process for it is designers who shape the interfaces between humans and machines. However, since there is no right or wrong in interactive artistic installations, I argue that robot-related artworks provide a unique opportunity for viewers to engage with robots in playful, creative and otherwise inaccessible ways that allow for innovation. Engaging with questions of design and communication in humanoid and non-humanoid robotic case studies, this presentation will a) explain the contribution of approaching robotics design and HRI from an artistic perspective, both theoretically and practically; b) discuss robotic artworks as practice-based research; c) propose a categorization of robotic artworks that contemplates the surprising contribution of so-called misbehaving, restricted or useless machines in a wider approach to the design of SARs.







## **Novel Minimally Actuated Snake-Like Robot for Industrial, Medical, Agricultural, Space and Search & Rescue Applications**

### **Dr. David Zarrouk, Mechanical Engineering**

#### **Minimally actuated serial robot: design and path planning, Yotam Ayalon, David Zarrouk**

In this research we present a minimally actuated overly redundant serial robot (MASR). The robot is composed of a planar arm comprised of ten passive rotational joints and a single mobile actuator that travels over the links to reach designated joints and rotate them. The joints remain locked, using a worm gear setup, after the mobile actuator moves to another link. A gripper is attached to the mobile actuator thus allowing it to transport objects along the links to decrease the actuation of the joints and the working time. A linear stepper motor is used to control the vertical motion of the robot in 3D space. Along the paper, we present the mechanical design of the robot with 10 passive joints and the automatic actuation of the mobile actuator. We also present an optimization algorithm and simulations designed to minimize the working time and the travelled distance of the mobile actuator. Multiple experiments conducted using a robotic prototype depict the advantages of the MASR robot: its very low weight compared to similar robots, its high modularity and the ease of replacement of its parts since there is no wiring along the arm.

#### **Path planning of a minimally actuated serial robot using A\* algorithm, Yanai Gal**

This research presents a minimally actuated Reconfigurable Continuous Track Robot (RCTR). The RCTR can change its geometry while advancing, thus enabling it to crawl and climb over different terrains and obstacles. The robot is fitted with a regular propulsion motor similar to a regular track and has a locking mechanism located at the front. The links have a unique design which allows them to be left loose to rotate between negative 20 to positive 45 degrees or be locked at zero or positive 20 degrees relative to each other as they reach the front of the robot. A release mechanism, located at the back, passively unlocks the links. As a result, all the links in the lower part are locked whereas the top links are unlocked. We first present the design of the robot and its mechanisms. Then, we model the kinematics and simulate the different shapes and obstacles that the robot can overcome. Finally, we present multiple experiments showing how this new robot can successfully navigate different obstacles.

#### **Minimally actuated continuous track robot, Tal Kislassi**

In planning for robotic manipulation, heuristic searches are commonly thought as impractical due to the high dimensionality of the problem, caused by the redundancy in the kinematic chain. In this paper we present an optimal motion planning algorithm for an overly redundant minimally actuated serial robot (MASR), using the manipulator's workspace, as a foundation for a heuristic search. We start by determining the work volume of the robot using optimized numerical probability method. Then we use the workspace as a search graph for the heuristic planning problem, which guarantees an optimal solution within the problem boundaries. By pre-planning which joints are necessary to be activated for the task, we can minimize the redundancy, reduce unnecessary complexities, and perform a much more effective heuristic search.

Along the paper, we present our workspace minimization and heuristic search for a general robotic arm and then implement the approach on a MASR model, a robotic arm with 5 passive joints and a single mobile actuator that is free to travel along the arm and separately rotate each joint. With set of simulations, we show how our minimal redundancy approach can benefit with path planning for traditional hyper redundant manipulators, and how it becomes even more effective when addressing the unique design of the MASR.





## From sound to movement:

### Assimilation of intelligent personal assistants among older adults

#### Technology Domestication in Later Life

Galit Nimrod<sup>1</sup>, Yael Edan<sup>2</sup>

<sup>1</sup>Communication Studies, <sup>2</sup>Industrial Engineering and Management

Technology domestication in old age may promote autonomy and support aging in place, but most previous research did not follow the process of domestication over time and in real life conditions. To gain deeper understanding of technology domestication in later life, we simultaneously explored uses, outcomes and constraints in real life conditions in a longitudinal study. Nineteen community-dwelling women aged 75-90 were provided with voice-controlled Intelligent Personal Assistants (Google Home) and their experiences with them were documented for three months via semi-structured interviews, observations, and weekly surveys. Analysis identified three different patterns of technology domestication: ‘Broad domestication’ characterized by a high level of integration and ongoing experimentation, ‘focused domestication’ in which the user mainly adopted one of the device’s functions, and ‘restrained domestication’ wherein a short period of experimentation was followed by occasional use, if any. Demonstrating that the process of technology domestication is not homogeneous, the findings call for some theoretical updates and offer several practical implications.

#### “Gymmy”: Designing and Testing a Robot for Physical and Cognitive Training of Older Adults

Maya Krakovski<sup>1</sup>, Shikhar Kumar<sup>1</sup>, Shai Givati<sup>1</sup>, Moshe Bardea<sup>1</sup>, Oded Zafrani<sup>1</sup>, Galit Nimrod<sup>2</sup>, Simona Bar-Haim<sup>3</sup>, Yael Edan<sup>1</sup>

<sup>1</sup>Industrial Engineering and Management, <sup>2</sup>Communication Studies, <sup>3</sup>Physical Therapy

Physical and cognitive training can maintain and improve older adults’ independence and quality of life. Given the demographic growth of the older adult population and the shortage of caregivers, there is a need for personal trainers for physical and cognitive activities. This study suggests that social robots can satisfy this demand and presents the development of “Gymmy”, a robotic system for the physical and cognitive training of older adults. The system design includes a humanoid mechanical-looking robot to demonstrate exercises, an RGB-Depth (RGB-D) camera to measure performance and a touch screen and speakers to provide instructions and feedback. Experiments with 26 older adults (65–84 years of age) were performed in home environments to examine the effect of users’ characteristics (age, gender, education and attitude toward robots), the addition of cognitive training and the success rate of the acceptability of a robot trainer. The results showed that age, attitude and education influenced the acceptance of the robotic system. The findings highlight the importance of customizing the system to the needs of different users and the role of meaningful feedback. The system was proven to be robust and reliable, demonstrating clear potential to be used as a personal trainer and as a means of motivating older adults.





## **Between Fear and Trust: Older Adults' Evaluation of Socially Assistive Robots**

**Oded Zafrani<sup>1</sup>, Galit Nimrod<sup>2</sup>, Yael Edan<sup>1</sup>**

**<sup>1</sup>Industrial Engineering and Management, <sup>2</sup>Communication Studies**

Socially Assistive Robots (SARs) are expected to support autonomy, aging in place, and wellbeing in later life. For successful assimilation, it is necessary to understand factors affecting older adults' Quality Evaluations (QEs) of SARs, including the pragmatic and hedonic evaluations and overall attractiveness. Previous studies showed that trust in robots significantly enhances QE, while technophobia considerably decreases it. The current study aimed to examine the relative impact of these two factors on older persons' QE of SARs. The study was based on an online survey of 384 individuals aged 65 and above. Respondents were presented with a video of a robotic system for physical and cognitive training and filled out a questionnaire relating to that system. The results indicated a positive association between trust and QE and a negative association between technophobia and QE. A simultaneous exploration demonstrated that the relative impact of technophobia is significantly more substantial than that of trust. In addition, the pragmatic qualities of the robot were found to be more crucial to its QE than the social aspects of use. The findings suggest that implementing robotics technology in later life strongly depends on reducing older adults' technophobia regarding the convenience of using SARs and highlight the importance of simultaneous explorations of facilitators and inhibitors.





## **AVR4Nano- Acoustic-Visual mobile Robotic manipulator for application of Nanostructures in agriculture**

**A visual-acoustic perception apparatus for robotic nanostructure application in vineyards**

**Edo Moran Wexler<sup>1</sup>, Omer Dadon<sup>1</sup>, Yossi Yovel<sup>2</sup>, Avital Becher<sup>3</sup>, Elena Poverenov<sup>4</sup>, Sigal Berman<sup>1</sup>**

<sup>1</sup> Dept of Industrial Engineering and Management, Ben-Gurion University

<sup>2</sup> Department of Zoology, Tel-Aviv University

<sup>3</sup> Institute of Agricultural Engineering, Agricultural Research Organization, Volcani Institute

<sup>4</sup> Department of Food Quality and Safety, Agricultural Research Organization, Volcani Institute

Nano-encapsulated materials delivered to their target zone by mobile robotic systems, offer a break-through method in precision agriculture. Such systems facilitate cost effective specific treatment, along with sustainability. The perception apparatus is central in mobile manipulators for spraying nano-encapsulated materials. Accurate, high-quality perception is required for identifying target zones and for directing the robotic motion. A perception apparatus integrating advanced vision and acoustic sensors was developed for a mobile-manipulator system for spraying nano-encapsulated Gibberellin on grape clusters in vineyards. The visual and acoustic sensor output is fused for creating a map of the detected grape clusters and for correctly guiding the spraying operation. The grape clusters are detected based on RGB images by applying the MASK-RCNN algorithm. The sonar verifies the image-based detection using a CNN and provides distance estimation based on the returning echo. The perception apparatus was integrated with the robotic system and tested in the laboratory and in the vineyard.

Acknowledgment: Project AVR4Nano, is funded by the Israeli Ministry of Science and Technology.

**Optimal manipulator characterization for selective spraying of nano materials in vineyards**

**Roni Azriel, Dept of Industrial Engineering and Management, Ben-Gurion University**

**Avital Bechar, Agricultural Research Organization, Volcani Center**

Robotic applications become more common in many counties and being designed for a variety of agricultural tasks. Although there is a great gain using robotic systems, they must perform those tasks optimally to have economic justification. This study suggests that a robot with kinematics suitable for a specific task will perform better than a universal robot expected to perform several tasks. To design the optimal robot, specialized tools based on simulation of robotized sites were used to find the optimum result for the multi objective function, based on selected performance metrics.

This presentation will show a method for characterizing an optimal robot for a specific well-defined task. The case study is a selective spraying task in a grape vineyard by a robotic manipulator where the purpose of the spraying described is to increase the fruit's size. The aim of the research is to characterize the best robotic arm to perform this task, in accordance with its limitations and constrains. The method of creating a database of robotic arms has been tested by implementation in the simulation environment that has been created. Primary results show that the kinematics of the manipulator significantly affect the performance of the task that been measured by primary metrics and a relation between the arm's movement ability in x and z axis and execution capabilities has been observed.





## Learning spraying profiles for robotic nanostructure application in vineyards

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The combination of nanostructures and mobile manipulators can lead to increased yield and quality, reduced production and operation costs, increased sustainability, reduced environmental impact, and improved working conditions with reduced health risks. The nanostructures must be applied precisely, according to the specific plant geometry, within the challenging agricultural environment. Therefore, devising suitable spraying profiles is imperative for ensuring required system operation. As part of a mobile robotic system developed for specific spraying of table-grape fruits with nano-encapsulated Gibberellin, we present spraying profiles developed based on reinforcement learning and based on classical surface coverage profiles. The profiles were developed and compared in a physical simulation environment. The classical coverage profiles were implemented in hardware and tested in the laboratory and in the vineyard. Results and insights will be presented.

