[1.] Mihai Gabriel MATACHE, [1.] Robert CRISTEA, [1.] Alexandru IONESCU, [1.] Mariana EPURE

ROBOTS FOR HARVESTING SOLANACEAE VEGETABLES – REVIEW

[1.] National Institute of Research - Development for Machines and Installations Designed to Agriculture and Food Industry - INMA Bucharest / Romania

Abstract: Agriculture domain represents one of the most important industries worldwide, as it the mainly source of food for all of mankind. Due to the latest socio-economic situation worldwide and taking into consideration aspects risen after the COVID pandemic, the number of manual labour workers available in agriculture is in continuous decline. As a result, researchers and engineers are working to develop new types of robots, appropriate for agricultural tasks, in order to optimize the yield and costs of agricultural crops. Within this paper a small review regarding the state of the art of agricultural robotics is presented, with emphasizing on robots for picking Solanaceae vegetables.
Keywords: agricultural robots, gripper, artificial intelligence, Solanaceae vegetables

1. INTRODUCTION

Agriculture is the oldest human industry, yet for sure in no stranger to technological changes. Industrial revolutions from XIX-th and XX-th centuries have replaced hand tools and horses driven ploughs with diesel engines and chemical fertilizers and pesticides.

Rising of global population has placed agricultural companies in a difficult position, being forced to produce more food in order to satisfy alimentary needs of billions of people, tackling at the same time severe environmental and economical challenges.

Governments and consumers are expecting more and more that the vegetables growers to use less pesticides and employing of seasonal personnel in farms gets more difficult each year. The lack of labor force threatens farmer's survival in many countries. As a result, agriculture is aiming at using autonomous machines as a viable alternative to human workers.

Each operation in agriculture could benefit of technological progress – from seeding and planting to crops nurturing and harvesting. Most of the actual agricultural technologies could be framed within three categories which are said to be the pilons of intelligent farm: autonomous robots, agricultural unmanned aerial systems (UAS) and sensors and Internet of Things (IoT).

Replacing human labor with automated systems represent an increasing tendency in many industries, as well as in agriculture. Most operations in agriculture are composed of repetitive and standardized tasks, an ideal domain for robotics and automation.

Farmers attention towards the newest technologies has transformed agricultural robots and drones into a market which is to achieve 23,06 billion dollars until 2028. At current time, robots can perform diverse tasks in open fields and greenhouses. From weeding, spraying and harvesting up to soil sampling, these advanced equipment helps farmers to sustainably grow healthy crops (*Top 10 agricultural robots that automate the business of growing food - Richard van Hooijdonk Blog*).

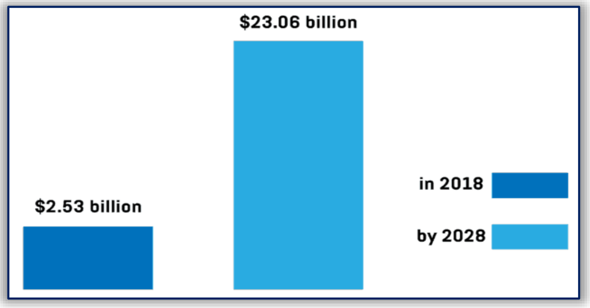


Figure 1 - The global agricultural robots and drones market (Global agriculture drones and robots market – Analysis and Forecast 2018-2028, 2019)

In development of digital agriculture, the agricultural robots have an unique role as they give a series of advantages for agricultural yield. From the inventing of first industrial robots in 1950, these machines started to be researched and developed at large scale.

Given the latest technologies in informatics, sensors and control equipment, agricultural robots have had a rapid evolution for different domains of the big agriculture industry. Despite all this, most of the agricultural robots continue to crave for intelligent solutions, being limited at small scale application without market maturity because their lack of integration with artificial intelligence (*Cheng et al., 2023*).

Intelligent agriculture and precision agriculture imply integration of advanced technologies into existent agricultural practices for increasing of yield efficiency and quality of agricultural products. As a

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

supplementary benefit, these improve also the quality of life for agricultural workers through replacing them from hard work conditions and repetitive tasks.

There are already agricultural robots which are starting to appear in farms and are performing tasks from planting and irrigating up to harvesting and sorting. Eventually, this new category of intelligent equipment will ensure production of more superior quality aliments with less workforce. (*Smart Farming—Automated and Connected Agriculture | Engineering.com*).

Yet, there is the concern that through introduction of agricultural robots, these will replace completely human workers, causing thus unemployment level increment. Josef Kienzle, from Food and Agriculture Organization (FAO) of the United Nations, affirms that this fear is groundless. Instead, robots are creating better workplaces throughout the value supply chain. In the end, transition to mechanization has the potential to bring new talents in industry (*Lenain et al., 2021*).

Autonomous technologies have the potential to reduce the dependence from migrant workforce and to eliminate the repetitive or dangerous tasks, agricultural robots providing the possibility of implementing new agricultural technologies by farmers. Robots offer also the possibility to improve products traceability and general quality.

Agricultural robots are automating slow, repetitive and boring operations for the farmers, allowing them to concentrate more on general management optimization. A classification of commune agricultural robots based on their performed action is as following:

— harvesting and picking agricultural products
— weeds control
— autonomous mowing, cutting, seeding, spraying and thinning
— phenotyping /monitoring
— sorting/packaging
— utilitarian platforms

Harvesting and picking is one of the most popular robotized applications in agriculture, because of the precision and speed which current robots could achieve, in order to improve yield and reduce waste leaved in the fields.

In figure 2 is presented the actual status of the agricultural robots' market, in function of the type of agricultural activities performed by them (harvesting vegetables/fruits, weeds killing, monitoring, livestock feeding, autonomous field spraying, autonomous mapping, autonomous drone spraying, manned robotic weeding implements, etc.) as also their technological readiness level.

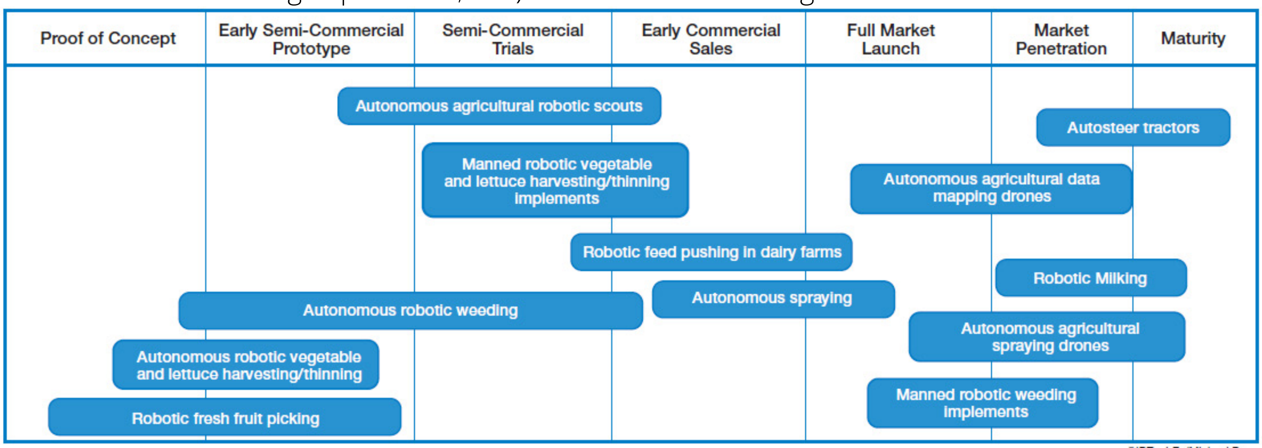


Figure 2 - Robots and drones: market and technology readiness level function of agricultural activities
(Michael Dent, IDTechEx, Lenain et al., 2021)

2. MATERIALS AND METHODS – AGRICULTURAL ROBOTS STRUCTURE

Robots and artificial intelligence can now be used at phesable costs for performing unstandardized tasks (e.g. picking fruits, selective weeding, crops detection) which were prior reserved to human workers. Thus, automation is not limited anymore at standardized works from agricultural production (e.g. ploughing, harvesting etc.). In addition, many workplaces in agriculture could be improved, but not replaced by robots. Often, robots will collaborate with human workers (*Marinoudi et al., 2019*).

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

Technological progress in detection and actuation, as also in automated learning, have allowed for many agricultural tasks to be phesable for machine automation. Such tasks vary in all crop stages, from field preparation and sowing, to monitorization and harvesting. Commercial agricultural robots are already available and is expected to appear many more in the following years as new technologies such as artificial vision and picking with specialized grippers will be more advanced (*Lytridis et al., 2021*).

Because of the practical requests for economical and efficient agricultural production, the agricultural robots categories are usually composed of field robots, fruit and vegetables robots and livestock caring robots (*Cheng et al., 2023*).

An agricultural robot must satisfy one or more tasks. This presumes implementation of three distinct functions which have to be carried out by the robot: scanning using sensors, data processing and establishing of future actions by using microcontrollers and execution through motors and servomotors.

Scanning function is assured by using sensors, cameras or external information system (GPS, RTK, GNSS) which allows for geo-positioning. Sensors provide information about the environment or internal components (e.g., obstacle position, internal temperature, battery status etc.). This information is used for establishing the right commands for motors, servomotors and execution elements.

Processing function is assured by a microcontroller or more, can vary in complexity. At reactive level, a robot could translate the raw information from a sensor directly in a command for an actuator. For more complex tasks, must be used algorithms. There could be used among others, simple or more complex mathematical functions, trigonometry, if-then conditions and other instruments, function of the programming language used (*Cheng et al., 2023*).

Execution function is done using execution elements, like motors and servomotors, grippers, lasers etc., electrically, hydraulically, pneumatically or mechanically driven.

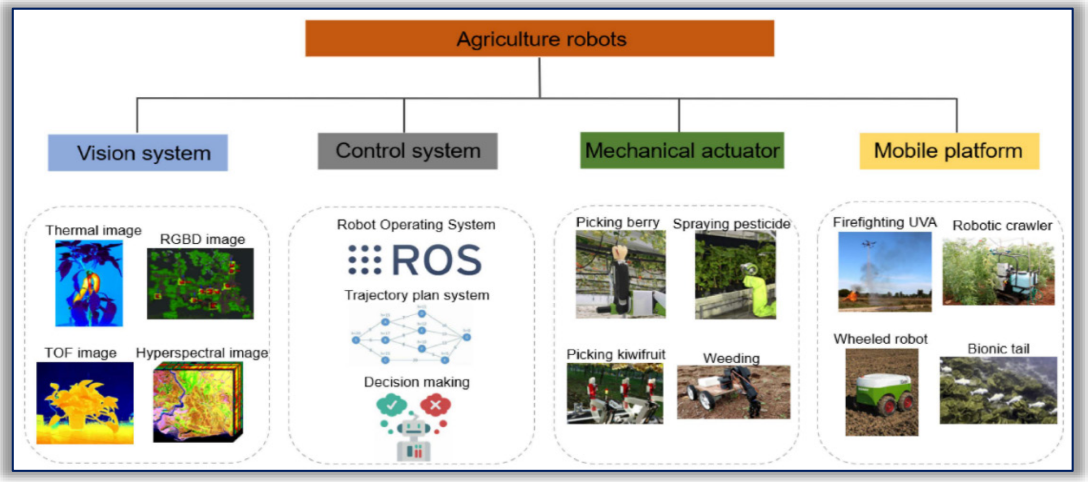


Figure 3 - Agricultural robots components *(Cheng et al., 2023)*

The working environment in agriculture is heterogenic, many times the work being performed in harsh conditions, dust, high humidity, high temperatures etc., so that the robots have to be heavy duty and equipped with precise navigation and capacity for obstacles avoidance. Thus, robots are composed at least of four components parts: a system of sensors and artificial vision, a control system, execution devices (gripper, suction cups, fingers, laser beam, cameras, etc) and/or a mobile platform for self-propelling

- Sensors and artificial vision system can transform recorded data in images using various cameras, like thermal, RGBD, TOF, 3D and multi-spectral, or through sensors (proximity, speed, altitude, torque, etc.) could provide important data for robot functioning.
- The control system has the role of decision making and movement planification.
- Execution devices have an essential role in robot functioning, through them being performed the function for which the robot was created (harvesting/picking fruits and vegetables, weeding, soil sampling, monitoring etc.).

— Mobile platforms allow robots to navigate through the crops, to avoid obstacles and to perform the programmed tasks.

3. RESULTS – ROBOTS FOR SOLANACEAE VEGETABLES HARVESTING

Picking of fruits and vegetables has represented a big challenge for production and market during harvesting season. Manual picking cannot fully satisfy the rapid requirements of every market, mainly because of high necessity for manual labor and time-consuming tasks as also because of aging and workforce deficit from the last years. Alternatively, intelligent robotics could be an efficient solution for raising planting surfaces dedicated to markets in combination with modification of growing, conservation and processing technologies (*Wang et al., 2022*).

The picking vegetables operation is difficult to automatize. For example, a robotic system developed for picking vegetables will encounter many obstacles. Vision systems have to determine localization and ripeness degree of the vegetable fruit in harsh condition, including dust, variable luminosity, temperature variations and wind created movement.

Also, there are needed more than just advanced vision systems for harvesting a vegetable. A robotic arm has to navigate in mediums with a lot of obstacles in order to delicately grasp and harvest the fruit, operation much more difficult than an industrial operation in which a part is picked and placed on a conveyer belt. The robotic arm has to be flexible in a dynamic environment and sufficiently precise as not to damage the fruits as they are picked.

The Solanaceae family includes several commonly collected or cultivated species. The most economically important genus of the family is Solanum, which contains the potato (S. tuberosum, in fact, another common name of the family is the "potato family"), the tomato (S. lycopersicum), and the eggplant or aubergine (S. melongena). Another important genus, Capsicum, produces both chili peppers and bell peppers.

Methods of robotized harvesting of vegetables from Solanaceae family use robotic arms or similar devices, endowed with specialized grippers for fruits harvesting, functioning on different principles for fruits detaching: through suction, mechanical grasping, stem cutting/crushing, shaking, hybrid, etc.

Following are presented several robots from technical state of the art, which function on different principles adapted to the specific of the Solanaceae vegetables targeted.

- Tomatoes harvesting robots
  — Robot for tomatoes harvesting through suction

In figure 4 is presented a robot for tomatoes harvesting developed by Wang et al., 2016. The end-effector (gripper-ul) for tomatoes harvesting is composed from three parts: fruits suction part, fruit grasping part and rotation part for stem breaking.

Figure 4 - Robot for tomatoes harvesting through suction *(Wang et al., 2022)*

The robot`s working procedure is as following: while a telescopic cylinder is used for sleeve extension up until the fruit is completely introduced into the sleeve, then the void generator is used for tomato sucking, thus fixing the fruit, and in the final stage the sleeve is rotated to cut the stem.

This type of harvesting robot was developed for harvesting greenhouse grew tomatoes. In addition, the tomatoes must be planted in rows disposed sideways a central rail system on which the robot is moving.

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

The measured performances of the robot are as following: 4,0 s for fruit localization, 12,0 s for moving the arm, 8,0 s for harvesting the fruits and 12,0 s for resetting the arm. The achieved success rate at tomatoes harvesting was approximately 83,9%.

— Robot for picking tomatoes in greenhouse

Wang L L et al., 2017 has developed a tomatoes harvesting robot composed of a four wheels platform with independent steering system, a 5 DoF (degree of freedom) robotic arm, a navigation system and a binocular vision system.

The platform on wheels is capable of assuring steering control at low speed, being based on Ackerman steering geometry system. For this robot was developed a shearing action gripper for tomatoes harvesting. Actions that the gripper has to performed are grasping, cutting and detaching tomatoes from the stem.

The gripper is composed mainly from a telescopic cylinder with a compressor, magnetiv valve, relay and scissors.

The working procedure of the robot is as following: the robot is moving along the planned path using the navigation system and the binocular system installed on the robotic arm starts to detect the riped tomatoes presence in the robot`s operation area, based on color difference between the background and the ripped fruits.

Once the tomatoes are detected, the mobile platform stops its movement, then the spatial coordinates of the ripped tomatoes as also the obstacles which could hinder the harvesting are determined by the artificial vision system, so that the mechanical arm could guide the end-effector until the targeted position is reached.

Then, the fruit is grasped and detached by the plant and deposited in the storage area. Afterwards, the arm is reset. The procedure is repeated until all fruits are harvested, then the mobile platform continues moving on the path.

— Tomatoes harvesting robot produced by MetoMotion

Autonomous robot produced by MetoMotion startup has two robotic arms for picking and harvesting tomatoes on both rows of the path simultaneously in high-tech greenhouses. The autonomously guided vehicle is endowed with visualization technology with 3G sensor and artificial intelligence which generate the tomato plant map.

The advanced visualization system detects ripped tomatoes and guide the robotic arms towards their location, which the cuts the stems and grasp the fruits clusters in a single operation, placing the fruits on a conveying belt before storing them in onboard fruits containers, working with a speed of 16 s per fruits cluster.

The arm pushes obstacles or hidden stems without damaging the crop. Once the robot has attained the row end, it stops and comes back at the beginning of the row, in order to unload the tomatoes.

Figure 5 - Robot for tomatoes harvesting (Wang et al., 2017): 1 - mobile platform; 2 - harvesting system; 3 - navigation; 4 - artificial vision system

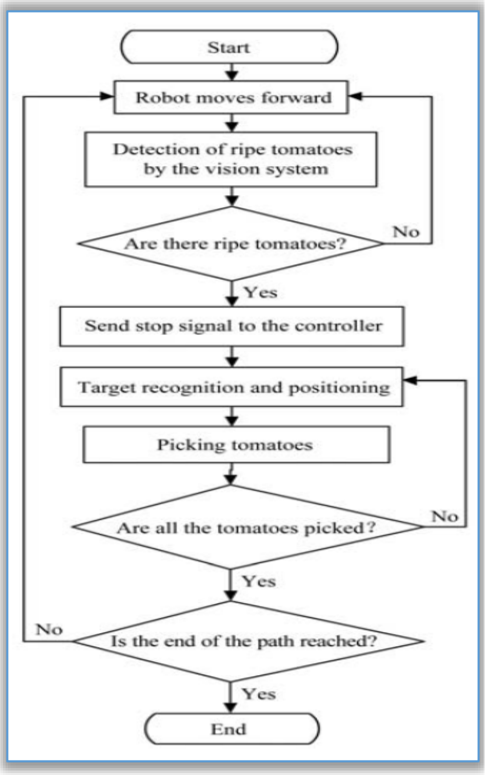


Figure 6 - Robot`s logical functioning scheme (Wang et al., 2017)

Figure 7 - MetoMotion produced robot (Israeli startup develops first AI robot for picking tomatoes | The Times of Israel)

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

— TakoBot- Continuum robotic arm for cherry tomatoes harvesting

The TakoBot continuum robotic arm proposed, was designed for satisfying the following requirements:

- Flexible structure for working in limited spaces
- Decent movement precision
- Loading capacity bigger than 100 g

TakoBot is a continuum robotic arm, discrete, hyper-redundant, controlled through cables. It is formed from three main parts: continuum arm, pretension unit and control box.

TakoBot pulls and slacks the cable using linear screws actuated by step by step motors, with a nominal torque of 0,49 N/m. In total, TakoBot uses four step by step motors: two for the first section and two for the second section. Each motor actuates two cables using push and pull principle.

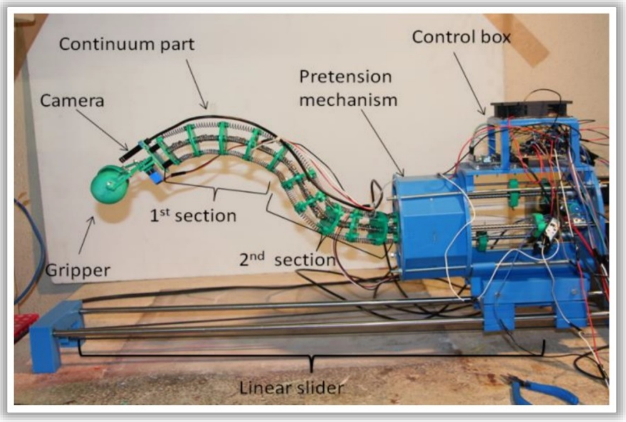


Figure 8 – TakoBot (Yeshmukhametov et al., 2022)

PEPPERS HARVESTING ROBOTS

— Robot for harvesting of cultivated in V frame

As could be seen in figure 9, Bac et al., 2017, has developed a robot for automated harvesting of sweet peppers cultivated in greenhouse on V frames. The equipment consists of a 9 DoF robotic arm, a pneumatic end-effector, an air compressor as also command and control equipment.

The color images are captured by the artificial vision system camera, for detecting the pepper fruit and evaluating it`s maturity. The identification of spatial coordinates of the fruit is done using a different depth camera. For obtaining a higher success rate the robot is endowed with multiple sensors. This robot could be used to tackle the complex structure of the plant, especially for its improved capacity to perceive and avoid obstacles in an adequate posture for fruits harvesting. Specific to this robot is the fact that the sensors module is physically separated from the arm, thus resulting in quite big overall dimensions.

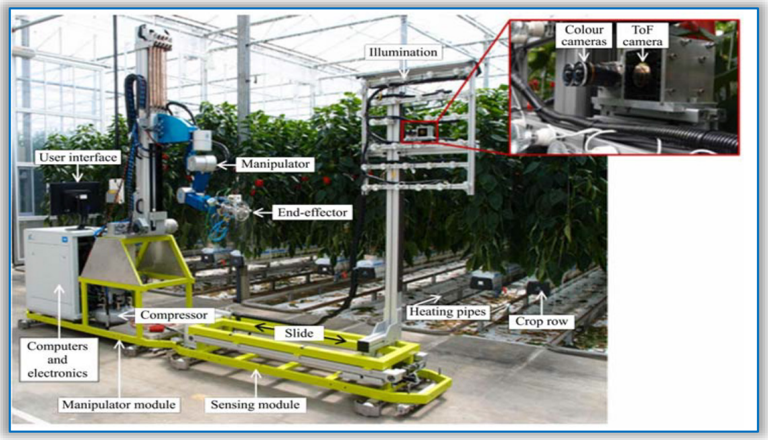
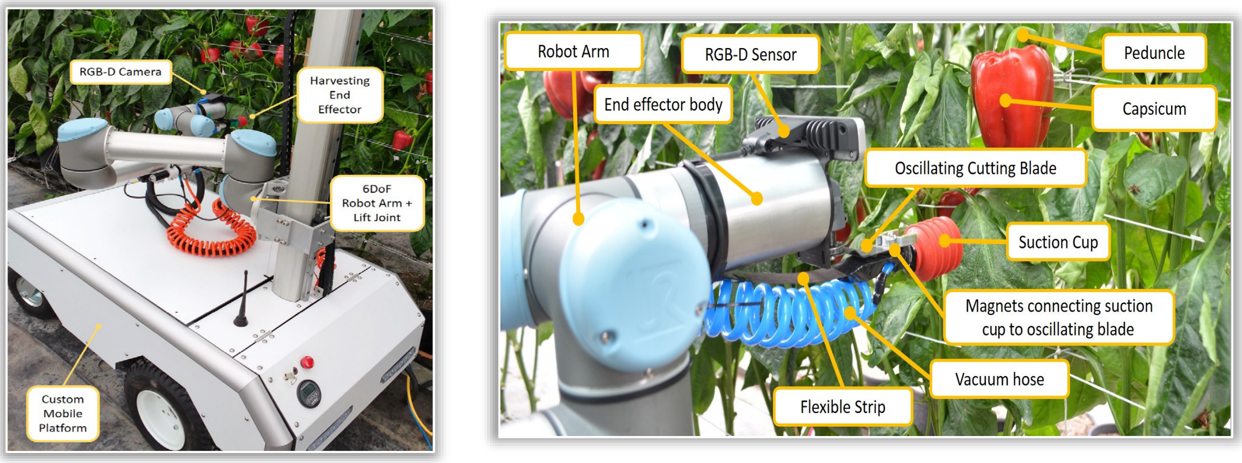


Figure 9 - Robot for sweet pepper harvesting *(Bac et al., 2017)*

— Robot for peppers harvesting in protected spaces

Lehnert et al., in 2017, has published a paper presenting a new robotic harvester for autonomous harvesting of peppers in protected culture spaces (solariums and greenhouses). One robotic arm with 6 DoF and a RGB-D camera was mounted on a mobile platform. The autonomous harvester functions based on a simple and efficient algorithm of artificial intelligence for fruits detection, a method of 3D localizing and grasping of the fruits and a new design for the end-effector for fruits harvesting. In order to reduce the complexity of path planning, the equipment was designed for working in protected spaces, where the plants are cultivated on planar trellis structures. The authors performed field tests for two pepper cultivars, the results obtained with minor plants modifications (leaves removal) showing a success rate of 58 % for harvesting (Claire cultivar), a success rate of 81% at grasping (Redjet Cultivar) and a success rate of 92% at stem detachment (Claire cultivar).



a) Robotic platform for sweet peppers harvesting b) End – effector with oscillating cutting blade

Figure 10 - Robot for harvesting of sweet peppers harvesting (Lehnert et al., 2017)

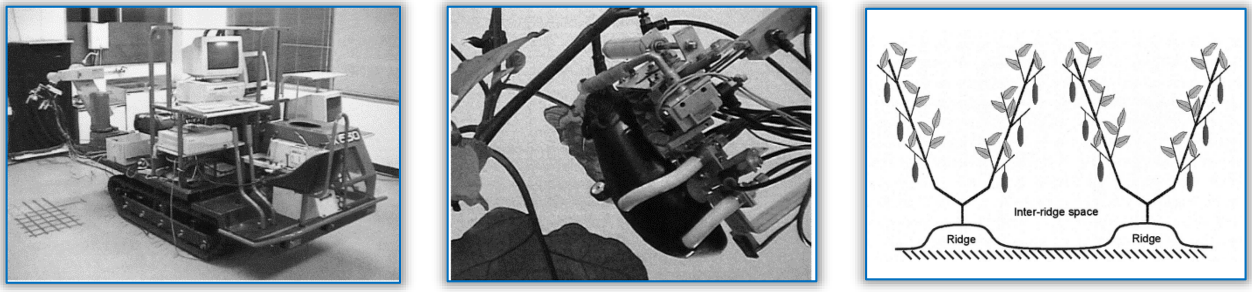
ROBOTS FOR HARVESTING EGGPLANTS

— Robot for harvesting eggplants cultivated in V frame

Hayashi et al., 2002, have developed a robot for harvesting eggplants cultivated in V frame technology. This robot consists of a 5 DOF robotic arm, a machine vision system and a mobile platform. The robotic articulated arm was fitted with a specialized end-effector for easily grasping the targeted eggplant through 4 rubber fingers and 2 suction cups, being provided with a cutting device for eggplant's peduncle.

The robot's harvesting procedure is as follows: firstly, the end of the robotic arm is controlled vertically, horizontally and on forward direction by the fuzzy control with visual feedback algorithm. After the end-effector touched the fruit, it starts the grasping task.

The photoelectric sensor attached at the end-effector base checks if the fruit is in effector's range, afterward the effector is moved up and down until is in position than the fruit is grasped. The arm then raises the fruit at 30° angle to separate it from the leaves, the peduncle is cut and the fruit is transferred into the container.



a) general view b) end-effector grasping eggplant c) V frame cultivation technology for eggplants

Figure 11 - Robot for eggplants harvesting (Hayashi et al., 2002)

— Robot for harvesting eggplants with two arms

The harvester robot proposed by SepúLveda et al. is composed of a system with two robotic arms and a platform with sensors. The robotic arms are Kinova MICOTM, fitted with Kinova KG-3 gripper. These arms are light and characterized by a reduced power consumption. Each arm is composed of six interconnected segments which offer 6 DoF, with a maximum payload of 2,1 kg in continuum functioning for a medium range, which are well suited for the gripper weight together with that of the

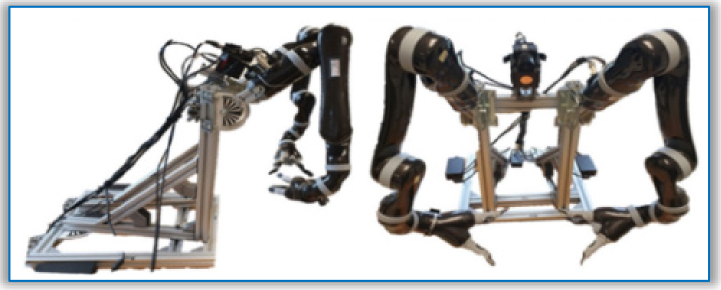


Figure 12 - Robot with two arms for eggplants harvesting (SepúLveda et al., 2020)

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

eggplants. The grippers are sub-actuated with a three flexible fingers. The fingers' opening-closing movements are driven by three linear actuators, allowing gripping objects with a force of 40 N. The gripper superior part can be fitted with a tool for cutting eggplants peduncles.

The vision system is formed by two cameras, one of them being Prosilica GC2450C type, which offers a high-resolution color image and the other one Mesa SwissRanger SR4000 type, which offers a surrounding point cloud. Prosilica GC2450C has 5,0 megapixels resolution, is GigE Vision compatible and incorporates a high-quality sensor which offers a superior image quality, excellent sensibility, reduced noise and a frame rate of 32 fps (frames per second). Mesa SwissRanger SR4000 camera is a measuring device which captures 3D infrared data of surrounding objects which reflect light. The distance measuring capacity is based on the time-of-flight principle. In nominal functioning mode a less than 0,01 m is achievable for a 10 m radius and a 50 fps frame rate. Both cameras are software triggered and are communicating on Ethernet. The software architecture is implemented in ROS (robot operating system) and consist of four modules, responsible for (i) image acquisition from both cameras, (ii) detection and localization of eggplants in the robot's space, (iii) movement planning and (iv) control of the two arms robot.

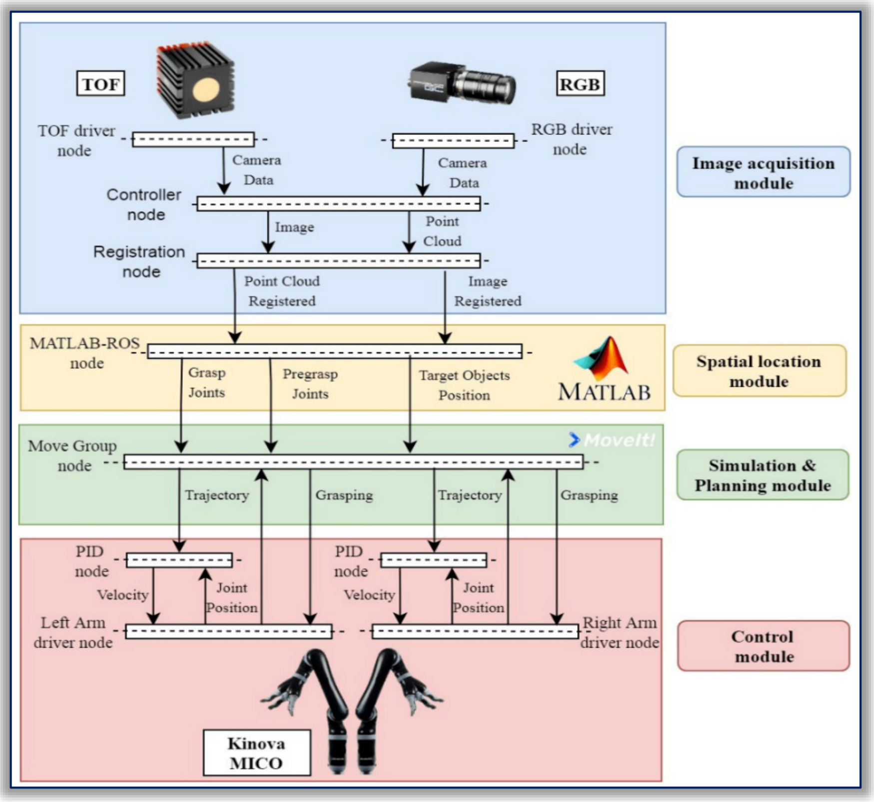


Figure13 - Software architecture of two arms robot (*Sepúlveda et al., 2020)*

4. CONCLUSIONS

The cultivation methods of fruits and vegetables could be structured between indoor cultivation (in solariums and greenhouses) and outdoor cultivation.

In outdoor environment there are complex and random perturbations during harvesting process. From them, the weather conditions could provoke a high variation of light intensity, temperature and humidity, affecting thus the artificial vision system performances. Also, fruits and vegetables will grow in places with high leaves and branches density, making more difficult avoidance of such obstacles by the robotic arm.

Indoor, there are less perturbator factors comparative with the outdoor environment. The indoor crops are realized in controlled medium both from the point of view of lighting and microclimate parameters as also of the cultivation technology and growing medium (soil, water, coconut shells etc.). In addition, ther are higher planting densities for indoor crops which allows for higher yields. For autonomous harvester robots, working indoor offers a more suitable environment for their optimal operation.

Performance of fruits and vegetables automated harvesting could be evaluated through the harvesting success rate, harvesting efficiency and the fruits damage degree. Harvesting success rate depends on the visual recognition of fruits in space and on the end-effector positioning algorithm. As a results, a higher harvesting success rate could be awarded to a higher fruits recognition rate (with a lower percent of false positive and false negative recognitions) as also to precision positioning within the artificial vision system, corelated with smaller errors of the end-effector harvesting operation.

Acknowledgement

This work was supported by a grant of the Ministry of Agriculture and Rural Development, contract of sectorial financing, ADER 2023-2026 type, no. 25.1.1, Technology for robotized harvesting of Solanaceae family vegetables in greenhouses and solariums, using artificial intelligence" and by Romanian Ministry of Research Innovation and Digitalization, through Program 1 - Development of the national research-development system, Subprogram 1.2 - Institutional performance - Projects for financing excellence in RDI, Contract no. 1PFE/30.12.2021.

References

[1] Bac C W, Hemming J, van Tuijl B A J, Barth R, Wais E, van Henten E J. (2017). Performance evaluation of a harvesting robot for sweet pepper. Journal of Field Robotics, 34(6): 1123–1139
[2] Cheng, C.; Fu, J.; Su, H.; Ren, L. Recent Advancements in Agriculture Robots: Benefits and Challenges. Machines 2023, 11, 48
[3] Hayashi S, Ganno K, Ishii Y, Tanaka I. (2002). Robotic harvesting system for eggplants. Japan Agricultural Research Quarterly: JARQ, 36(3):163–168
[4] Lehnert C, English A, McCool C, Tow A W, Perez T. (2017). Autonomous sweet pepper harvesting for protected cropping systems. IEEE Robot Automation Letters, 2(2): 872–879.
[5] Lenain R., Peyrache J., Savary A., Séverac G., (2021). Agricultural robotics: part of the new deal? FIRA 2020 conclusions: With 27 agricultural robot information sheets. Versailles, éditions Quæ, 80 p
[6] Lytridis, C.; Kaburlasos, V.G.; Pachidis, T.; Manios, M.; Vrochidou, E.; Kalampokas, T.; Chatzistamatis, S. (2021). An Overview of Cooperative Robotics in Agriculture. Agronomy, 11, 1818
[7] Marinoudi, V.; Sørensen, C.G.; Pearson, S.; Bochtis, D. (2019). Robotics and labour in agriculture. A context consideration. Biosyst. Eng., 184, 111–121.
[8] SepúLveda D., Fernández R., Navas E., Armada M. and González-De-Santos P. (2020). "Robotic Aubergine Harvesting Using Dual-Arm Manipulation," in IEEE Access, vol. 8, pp. 121889-121904
[9] Yeshmukhametov, A.; Koganezawa, K.; Yamamoto, Y.; Buribayev, Z.; Mukhtar, Z.; Amirgaliyev, Y. (2022). Development of Continuum Robot Arm and Gripper for Harvesting Cherry Tomatoes. Appl. Sci., 12, 6922
[10] Wang L L, Zhao B, Fan J W, Hu X A, Wei S, Li Y S, et al. (2017). Development of a tomato harvesting robot used in greenhouse. Int J Agric & Biol Eng, 10(4): 140–149.
[11] Wang X N, Wu P H, Feng Q C, Wang G H. (2016). Design and test of tomatoes harvesting robot. Journal of Agricultural Mechanization Research, 38(4): 94–98.
[12] Wang Z H, Xun Y, Wang Y K, Yang Q H. (2022). Review of smart robots for fruit and vegetable picking in agriculture. Int J Agric & Biol Eng, 15(1): 33–54.
[13] ***Global agriculture drones and robots market – Analysis and Forecast 2018-2028. (2019) BIS Research.
[14] ***https://blog.richardvanhooijdonk.com/en/top-10-agricultural-robots-that-automate-the-business-of-growing-food/
[15] ***https://www.engineering.com/story/smart-farming-automated-and-connected-agriculture
[16] *** www.timesofisrael.com/israeli-startup-develops-first-ai-robot-for-picking-tomatoes/

Note: This paper was presented at ISB–INMA TEH' 2023 – International Symposium on Technologies and Technical Systems in Agriculture, Food Industry and Environment, organized by University "POLITEHNICA" of Bucuresti, Faculty of Biotechnical Systems Engineering, National Institute for Research–Development of Machines and Installations designed for Agriculture and Food Industry (INMA Bucuresti), National Research & Development Institute for Food Bioresources (IBA Bucuresti), University of Agronomic Sciences and Veterinary Medicine of Bucuresti (UASVMB), Research–Development Institute for Plant Protection – (ICDPP Bucuresti), Research and Development Institute for Processing and Marketing of the Horticultural Products (HORTING), Hydraulics and Pneumatics Research Institute (INOE 2000 IHP) and Romanian Agricultural Mechanical Engineers Society (SIMAR), in Bucuresti, ROMANIA, in 5–6 October, 2023.

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665