FLEXIGROBOTS

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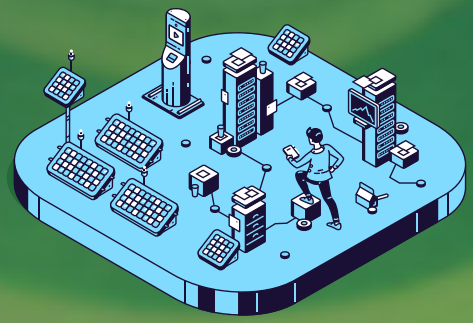

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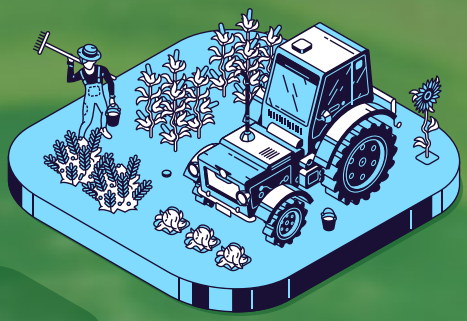


This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101017111.

Project Updates

WP2 – Requirements, architecture and standardisation

WP2 focuses on analysing various aspects related to the design of the FlexiGroBots platform such as its requirements, architecture and standardisation.

The last six months have been mostly dedicated to work to achieve results reported in the D2.8 deliverable completed at the end of the 2022. This deliverable, entitled "Pilot alignment and joint assessment report 2", presents the common methodology being followed to ensure alignment between the three FlexiGroBots pilots implemented in four different locations (Spain, Finland, Serbia and Lithuania) and for three different crops (grapevines, rapeseed, blueberries), even addressing diverse agricultural tasks such as pest detection and treatment (weeds, diseases...) or harvesting assistance.

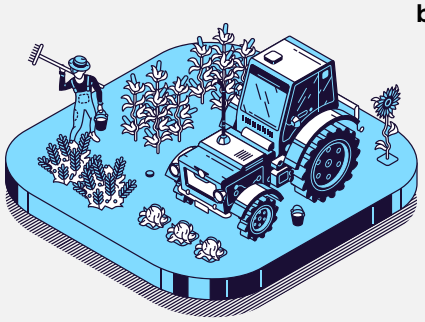
In this richly diverse context, **the work has been particularly focused on defining how pilots can collaborate and share the results** so that all pilots can benefit from the work of the whole. Thus, the aim is to align the three pilots, so that they follow a common approach during development that also allows the FlexiGroBots platform to meet the requirements of all pilots.

For each pilot, specific elements have been identified that can be beneficial for other pilots. Thus, it has identified some common elements in several areas: from the datasets (used and collected) to the devices used (both robots and other types of devices), as well as the AI models, which could be implemented in the context of a pilot or the FlexiGroBots platform.

The impact of these last three aspects (data, robots/devices and models) is very relevant, as sharing them among pilots can lead to more efficient AI models, since they can be trained with more data and validated in more environments. It also leads to the implementation of more complex scenarios by using AI models and devices from other pilots, as well as more ambitious multi-robot systems, as the joint use of robots from multiple pilots makes it possible to implement more complex and realistic scenarios.

Blog post: Ethical & Technical Documentation for Machine Learning with Model Cards and Datasheets

WP3 – Platform development



The aim is to develop the common FlexiGroBots platform and the building blocks that support its implementation. The platform will satisfy the stakeholders' requirements and it will enable the reference architecture for mission control systems for heterogeneous robots' fleets.

During the last months, the goal has been kept: develop a platform that enables the integration of a number of building blocks required within the scope of the project but that were initially isolated from each other. The work done up to the middle of the project had allowed considerable progress in this regard.

Click HERE and read about FlexiGroBots platform v1

Additionally, **the improvements conducted by the project partners in recent months have been directed at the integration of the components and the usability of the platform itself**.

From now until the end of the project, the challenge is to continue improving the platform so that it can be easily used as a reference solution in the management of heterogeneous fleets of robots in the field of precision agriculture.

The progress in this regard has continued to be uploaded to the project's GitHub repository.

Regarding each of the **components of the platform**, the main advances corresponding to the AI subsystem –which is based on Kubeflow – have consisted in improving the implementation of AI pipelines for the development of application models useful for pilots. Moreover, the AI subsystem is now ready to deploy these models as inference services.

The achievements in relation to the **Data Space** are probably the most relevant in terms of component integration. This is thanks to the fact that it has been possible to develop components that allow linking the operation of the Data Space with the Data Lake of the AI subsystem – which is deployed using MinIO.

Blog post about Data Space

In addition, it has been agreed how to improve the integration of the AI subsystem with the Data Space itself so that users are able to consume data catalogs published within the Data Space directly in Kubeflow. The architecture of this solution is included in the deliverable D3.2, which corresponds to the second version of the platform.

For **geospatial enablers** and services, the Open Data Cube instance has been kept running to accommodate the needs of the Spanish pilot (vineyards). For this, besides to continuing to support the catalogs coming

from Sentinel 2, the process of automatic generation of catalogs from the orthomosaics coming from the Spanish pilot drones (UAVs) has been improved. Therefore, new data from UAV flights and Botrytis datasets have been migrated to the Open Data Cube and the MapServer service – the component in charge of serving other types of information but georeferenced images.

Blog post: Geospatial enablers and services

New assets have been developed within the framework of the **common application services**.

The applications that are currently available cover the following needs: SLAM; people detection, location, and tracking; people's action recognition; moving objects detection location and tracking; anonymisation; dataset generation; disease detection in fruits; pest detection in crops; weed detection; and orthomosaic generation. The following steps, aligned with the integration goals, will be the deployment of these applications as inference services in Kubeflow to be used by the rest of the components – such as UGVs and UAVs– that built up the complete technological solution.

Blog post: Common Application Services

The **Mission Control Centre**, the last block – and by no means least – that makes up the platform, has been improved through the continued development of its main components, such as the Farm Mission Workflow Manager, the Robot Fleet Mission Controller and Supervisor, and the Robot task planner. In the same way, the work for the coming months will be the completion of the pending components and their redeployment as part of the centralised platform infrastructure.

WP4 – Pilot 1: Grapevines

Pilot 1 focuses on precision agriculture for grapes. It has three use cases that involve the use of five different technologies that are being developed during the project:

- Automate field inspection for early detection of Botrytis in grapes – UAVs and UGVs
- Automated precision spraying – UGVs
- Reduce the time and cost of transporting grapes from the vines to the winery – UGVs

Summer: the grape harvesting season

The partners of WP4 traveled to Terras Gauda's (TER) facilities during the 2022 summer, which is the harvesting season for grapes. During this campaign, TER inoculated Botrytis in a selected plot of the vineyard to ensure the presence of the disease.

Partners from CSIC and Wageningen University (WU) acquired imagery data and field-tested the algorithms and models that are being developed for the pilot. This was done for both UAVs and UGVs for the **Botrytis detection use case**.

For the **harvest support use case**, CSIC tested out the algorithms to gain insights and receive feedback. They also performed some test runs that helped designing the final KPI measurements that will take place in 2023.

Autumn: continue development

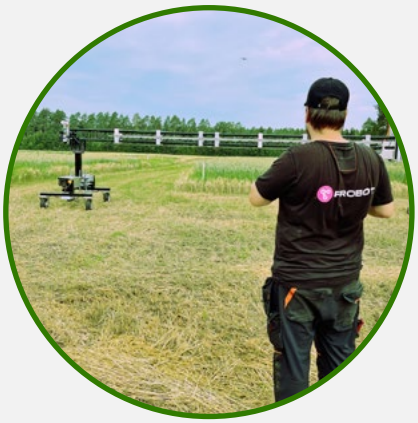
After the harvest campaign where new datasets were acquired, partners from WU and CSIC had to sort, prune, and label the data to turn it into useful datasets. Months M21 to M24 focused on algorithm development, as well as writing scientific papers and attending the ROBOT2022 conference.

Seresco (SER) continued improving the functionalities of the **Decision Support System**, specially by integrating the FMIS with the FlexiGroBots platform and the rest of the Pilots. SER built a connector for the **IDSA Data Space**, successfully sharing data from Pilot 1 with the rest of the consortium. They also started working towards the integration between the FMIS and the **Mission Control Centre**.

READ THE RESEARCH ARTICLE

WP5 – Pilot 2: Rapeseeds

The Rapeseed pilot focuses on piloting solutions in pest management, weeding and harvesting of silage.

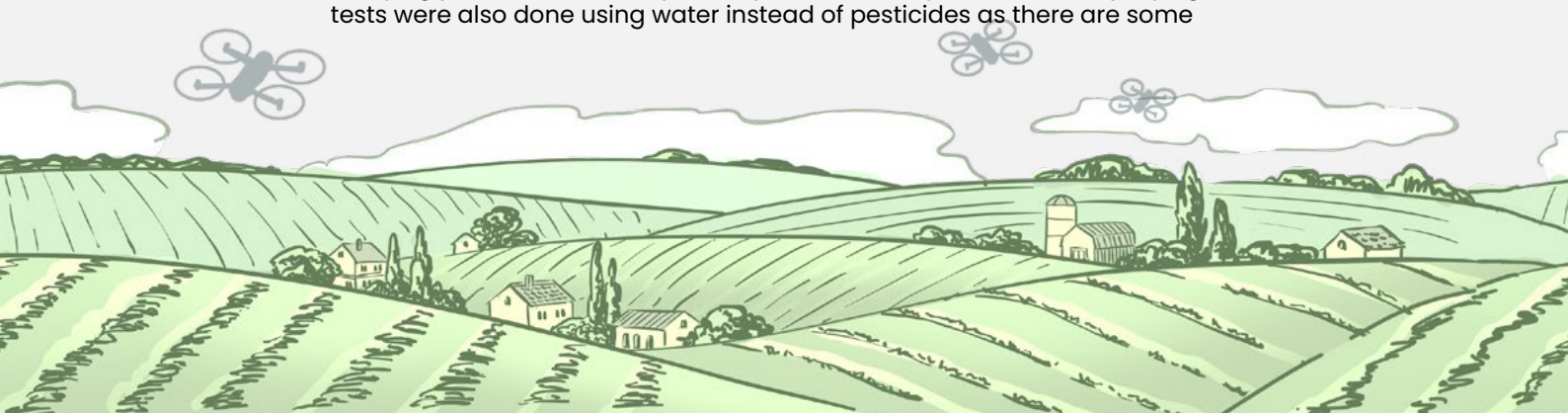


The second summer of the rapeseed pilot was spent on testing various robot units and with collecting of additional data for the AI services needed. During the autumn the focus shifted to the development of platform services for the pilot. **All use cases for the Finnish pilot made significant progress as more complete robot units were ready for testing**.

In the **silage harvesting use case** all three main parts were tested. The silage timing analysis service was up and running as part of the Mtech farm information management system. The LUKE's autonomous tractor was tested in a real pilot environment.

The autonomous tractor was able to drive through the planned route, to do the needed turns, and to control the implement as planned. In the situation awareness service, the VTT's surveillance drone followed the autonomous tractor in the air and other tractors were identified from its video stream.

In the **pest management use case**, all main three mission workflow phases were experimented by LUKE. The autonomous imaging flights were done. Images were analysed using a pest detection model, and an autonomous spraying task was tested with a spraying drone. The pest detection from aerial images turned out to be very challenging and error prone and we are now studying possibilities to use pest traps and to analyse those. The spraying tests were also done using water instead of pesticides as there are some

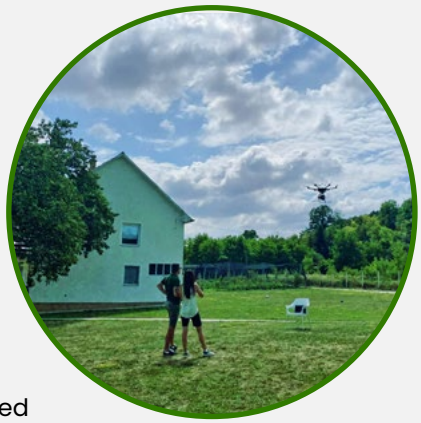


legal and environmental constraints.

In the **Rumex weeding use case**, the PROBOT completed the development of their field robot platform. The platform was tested at the pilot site in Ruukki. The weeding arm and tool development continued at VTT with posture detection and force control development. Both functionalities are ready, and the plan is to integrate the platform and the weeding tool in early 2023.

WP6 – Pilot 3: Blueberries

Pilot 3 is dedicated to blueberry production across Europe with test sites in Serbia and Lithuania. **The goal of the pilot is to develop UAV-driven systems for crop monitoring** (yield assessment and weed/disease detection) **and UGV-based systems for weed eradication/spraying and automatic soil analysis**.



As the blueberry fields are usually located in remote rural areas, we built an "artificial blueberry orchard" at university premises for quick design-implement-test cycles.

The artificial orchard consists of plastic ridges and bushes, along with compartments with the real soil for testing of the soil sampling and analysis module.

This cut the time needed for testing the individual UGV components and allowed for quick design updates and better preparation of field tests in hilly rural areas. In this setup, we worked on the UGV sprayer development and tested a number of designs in the lab.

Regarding the UAVs, we acquired new datasets using multispectral and hyperspectral cameras on different drones in the two countries. We used these datasets for additional training and validation of image processing algorithms, for running novel neural network architectures for image segmentation, zone delineation and detection of weeds and diseases.

As crop monitoring and soil sampling modules are now fully functional, **in the next period** of implementation **we will focus on weed spraying and intense testing of the technology in blueberry orchards**.

WP7 – Dissemination and Exploitation

Within the past six months of the project, WP7 continued with the implementation of its tasks according to the timeline and the work plan foreseen in the proposal. More specifically, **T7.1 and T7.2 continued their work on the Dissemination & Communication of the project's activities and results i**ncluding the first three scientific publications of the project and the uploading of a second open-source UAV dataset of the vineyard as a result of the summer flights developed by WU from July to September, and containing more than 70 new datasets. In September 2022, WU presented novel results regarding the detection and tracking of grape clusters at the IPPS2022 conference, while in November 2022, a group of partners organised and participated in a project event under the scope of ROBOT2022 conference in Spain. Also, the synergies with other European projects were further developed, such as the one with the VIRAL project, for which the most updated FlexiGroBots' results were presented at the SmAgTech EXPO 2022 conference. On the Communication aspect, a total of ten blog posts on various topics written by partners were published. At the beginning of August 2022, the second official press release was published, which was followed by several guest appearances on TV shows and numerous press articles. Also, a few months after that, the project coordinator gave an interview for Horizon Magazine. Finally, in December 2022, the D7.11 deliverable was successfully submitted.

When it comes to the **business modeling & ecosystem building aspect, T7.3** finalised the first version of the report on business modeling and ecosystem building where the first results on the potential future exploitation of the project's outcomes were included as well as the collaboration with and the utilisation of relevant DIHs in this process. The deliverable was successfully submitted in December 2022. In parallel, T7.4 continued its work on the development of a clear guideline with concrete action points on the upcoming on-field demonstration events in collaboration with the partners involved in the development of the pilots.

Finally, **a new task was initiated by CEPS, T7.6 "Ethical assessment of AI and Agrifood"**. The task is partly a continuation of CEPS' evaluation of the ELSE factors, which ought to be expanded towards the final version of a trustworthy AI model for precision agriculture. The research is broken down into several work streams. About to be completed is an analysis on the topic of IP law and licensing standards for data sets and models. The most complex work stream aims to explore optimal agri-food data spaces for trustworthy AI applications to precision agriculture. The guiding question focuses on the requirements for establishing an optimal data space, combining insights on the value of data, contracting standards and data ownership in shared data spaces, with an optimal model of an agri-food data marketplace.

News & Events

Peltopäivä (Field Day) 2022

16/08/2022 | RUUKKI, FINLAND

In addition to **LUKE**, who was one of the organizers, FlexiGroBots partners **VTT** and **PRO** also participated in the exhibition, whereby PRO's visit was followed by robot test runs carried out in a nearby field.

IEEE RO-MAN 2022

29/08/-02/09/2022 | NAPLES, ITALY

CEPS participated in the IEEE RO-MAN 2022 conference, where **Moritz Laurer** and **Artur Bogucki** presented CEPS' research on model cards and datasheets reporting standards for models and datasets. A summary of this research will be published as a paper in a special issue from the conference.

Inno panorama 2022

22-24/09/2022 | KAUNAS, LITHUANIA

ART21 and **AFL** have a booth where they presented the project/activities/technologies and discussed with attendees about them, introduced them and tried to understand their perspective on the potential use of these technologies. Also, **AGS** had a booth where presented the project.

7th International Plant Phenotyping Symposium – IPPS 2022

27-30/09/2022 | WAGENINGEN, NETHERLANDS

WU participated in the IPPS 2022 with a poster presentation on "Automatic tracking of grape clusters and early phenotyping from UAV video sequences". At the same time, **Sergio Vélez** and **Mar Ariza Sentís** from WU presented the **FlexiGroBots** project to the VIRAL project members.

Fruit Attraction

04-06/10/2022 | MADRID, SPAIN

CSIC participated in the Fruit Attraction fair and they presented the **FlexiGroBots** project and the latest developments in collaboration of **UAVs** and **UGVs** in early pest detection and precision treatment, as well as a **prototype robot** for assisting in manual harvesting.

MaatalousKonemessut (Agricultural machinery trade fair)

13-15/10/2022 | HELSINKI, FINLAND

LUKE and **PRO** presented the **FlexiGroBots** project at the Innovation Market within MaatalousKonemessut, where they had daily interviews/pitches. Also, **Mikko Hakojärvi** presented project activities for interested customers at the **MTE** booth.

23rd IBIS seminar

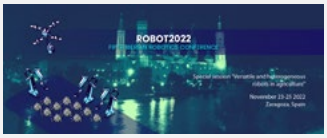
20-21/10/2022 | DANUBIA HOTEL, SILVER LAKE, SERBIA

Dr. Damir Krkljes from **BIO** gave a presentation on "Advanced Solutions in Agri-food Sector and Environmental Monitoring by BioSense" at the seminar. Seminar attendees had the opportunity to hear more about the aims of the **FlexiGroBots** and the **robot Gari**.

SmAgTech EXPO 2022

23-24/11/2022 | ONLINE

On the second day of the conference, **Sergio Vélez Martín** and Maria **Del Mar Ariza Sentís** from **WU** held a presentation entitled "Drones for precision agriculture: using remote sensing to help farmers and winegrowers to manage the spatial variability within vineyards".



FlexiGroBots Project Event 2022

23-25/11/2022 | ZARAGOZA, SPAIN

A special session entitled "Versatile and heterogeneous robots in agriculture" included several topics covered by the **FlexiGroBots** and is being organized by partners from **WU** and **CSIC**. Within this special session, three papers written by consortium partners were presented at the conference.

The XX CIGR World Congress 2022

05-10/12/2022 | KYOTO, JAPAN

FlexiGroBots presentation considering spraying drone regulations was presented by **Ari Ronkainen** from Natural Resources Institute Finland (**LUKE**), one of the consortium partners.

2nd Official Press Release

10/08/2022

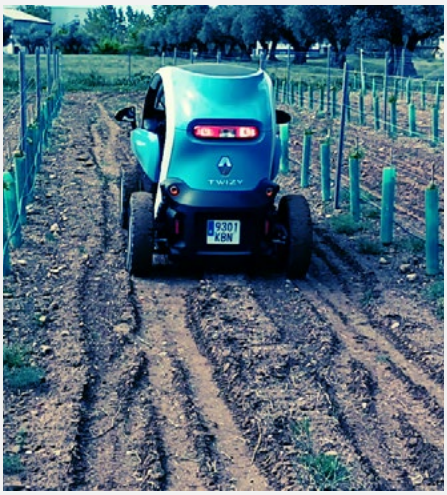
BIO prepared the **FlexiGroBots second official press release**, which was published on the project website on August 9, 2022. The content entitled "FlexiGroBots is successfully building an innovative platform to help farmers" was shared with all consortium partners along with instructions for publication within their channels and social media posts.

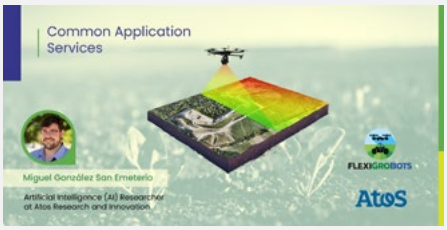
First Review Meeting

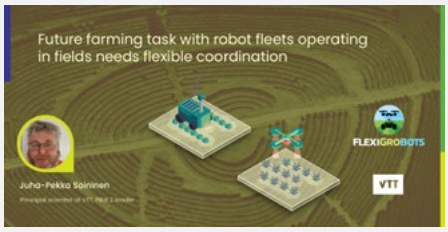
19/10/2022 | ONLINE

On **October 19, 2022, FlexiGroBots** had its **first review meeting**. The project coordinator, as well as the leaders and participants of all seven work packages presented to the European Commission officers the significant results achieved by the project's halfway mark of 18 months. In addition, the steps that are planned to be taken in the coming period were discussed.

Blogs







Meet FlexiGroBots Partners

Seresco

Seresco is a Spanish IT company specialised in complex, sophisticated and essential technological solutions for public and private entities. Founded in 1969 in Oviedo, where it is headquartered, it currently has international branches in Portugal, Peru, Colombia and Costa Rica. The company has 50 years of experience in providing services in the areas of personnel and payroll administration, digital transformation, land registry management, IT infrastructure and services, cybersecurity and tailored software development.O

Seresco participates in European innovation programmes through its department of Agriculture, which specialises in software for precision agriculture and management of agricultural, livestock and forestry operations. Its main product is CULTIVA, a Farm Management Information System that helps the end-users to make better, informed decisions.

Within FlexiGroBots:

Seresco has a wide presence throughout the project, participating in five different work packages. As a coordinator, Seresco leads the WP4, which corresponds to Pilot 1 – Grapevines, as well as tasks T4.1, T4.3, T4.4 and T7.5. They also collaborate as partners and stakeholders in the definition of the platform architecture, software standards, ELSE factors and project sustainability.

As a technical partner, Seresco develops, manages and operates Pilot 1's Farm Management Information System, which is at the same time a Decision Support System.

Seresco's FMIS allows the end-users to digitally monitor and operate its farm in an user-friendly way, from sensors and agronomic actuations to robotic operations in the field. The FMIS integrates layers of data and third-party

services to make available to the user the following services:

- Geospatial data. The Open Data Cube developed within T3.3 is fully integrated with Pilot 1 through the FMIS.
- Meteorologic forecast. Seresco installed field sensors in the vineyards. They use aggregate data for farm analysis and decision support. As part of T3.2, Seresco has developed an IDSA Connector to make this information available to the rest of the consortium through FlexiGroBot's Data Space.
- Robotic and drone telemetry. As part of T3.5, Seresco is integrating the unmanned vehicles fleet with the FMIS through the Mission Control Centre.
- Algorithm-based heatmaps. The FMIS shows layers of heatmaps over drone and satellite imagery of the field. Those heatmaps are the result of the software models developed by WUR within T4.2.
- Registration of agronomic actuations. This is a core part of Seresco's FMIS.
- Yield mapping. This is another core functionality of the platform.

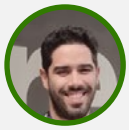
By means of its innovative platform with great capacity for integrating third-party solutions, Seresco aims to bring digital transformation to European farms. They focus their efforts in reducing the amount of chemical contaminants, increasing yield of sustainable food systems and improving the overall life quality of farmers.

Sergio Álvarez Fernández,

Pilot 1 leader. MSc in Telecommunications Engineering. He has participated in diverse international R&D initiatives at research or management levels and is currently the Head of Innovation at Consulting & Software Department.

Ismael Suárez Cerezo,

He has long experience as a coordinator and manager of R&D projects, his main technical background is in systems and database administration.

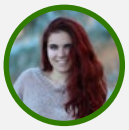


Víctor Nistal Freije,

Long experience in web software and platforms design and development, system's architecture, and deployment. Specially focused in the last years on precision agriculture and farm management systems.)

Miguel González San Emeterio,

MSc in Physics with expertise in deep learning technology for computer vision solutions. At Seresco he works at project management and business development for innovation projects.



Mónica Cueva González,

Web engineer that works on the analysis and development of web applications for research and innovation in different sectors, mainly in precision agriculture software.

Damián Prieto López,

Graduate in software engineering from the University of Oviedo. For the last 5 years, he has been working at Seresco developing technical tasks and has functional experience in the field of precision agriculture and grapevine cultivation.

Probot Oy

Probot Oy is a high-tech robot company based in Oulu, northern Finland. The company has been building various types of robotics and automation since 2006. The size of the team is 20 people, who are all highly talented and motivated in solving real-world challenges with automation and robotics. The company was originally founded for fulfilling the gap between Industry and Academia – And based on that purpose, the company still operates in two main areas: 1. Traditional industrial automation and robotics, including mobile robot logistics and 2. Next-generation robotics and automation (agricultural robotics, extended reality and robotics) – Providing the latest technology for the customers.

Within FlexiGroBots:

In the FlexiGroBots project, Probot Oy designs, integrates and demonstrates a robot platform for Rumex weeding. The work is done in close collaboration with the VTT (Technical Research Centre of Finland), which is focusing especially on recognizing and localizing the weed – And passing the information for the field robot by Probot Oy. For the project-related demonstration, the company is preparing a field robot platform for field operations and integrates the weeding mechanics (created by the VTT) as a part of the robot. The wider use of robotics in agriculture needs reliable references and demonstrations like the one done in the FlexiGroBots project. The partnership in FlexiGroBots plays a key role in the Probot Oy strategy for opening new markets in the agriculture industry and automation on the field.

probot.fi
@ProbotOy
probot

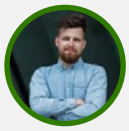
ART21

ART21 is an SME-sized agri-food technology innovation house from Vilnius, Lithuania. Since its establishment in 2007, the company has become a leading innovation developer for the agriculture, food and associated industries in the Baltic states. The R&D&I activities of ART21 are focused on advanced ICT domains such as Artificial Intelligence and data analytics, spectrometry and remote sensing, utilization of EO, UAV and GIS-based technologies, IoT and Robotics, distributed ICT systems, industrial ERP solutions, etc. – all implemented in accordance to the needs of agri-food sector stakeholders. The company team is composed of over 40 scientists, engineers, software developers and project/business managers with diverse competencies.

ART21 is participating in large-scale EU innovation projects and various national R&D&I programmes and initiatives. The company is also a core member of EIT Food and a founding member of the Digital Innovation Hub AgriFood Lithuania.

Within FlexiGroBots:

In the FlexiGroBots project, ART21 is leading WP7 on Dissemination and Exploitation, is the main contributor to Pilot 3 on blueberries monitoring led by BIO and finally, is contributing also to the development of the FlexiGroBots platform, led by ATOS.



Tomas Bunga

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Thomas Gitsoudis

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