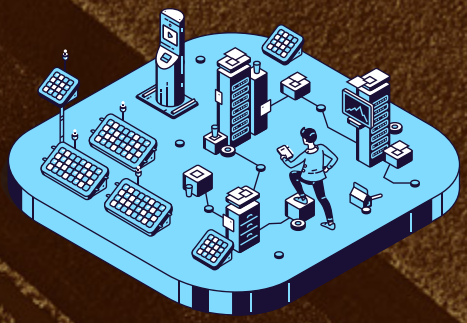
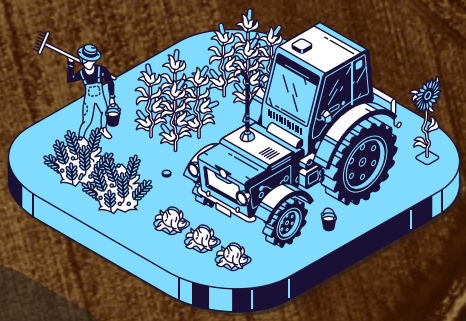
FLEXIGROBOTS

Contents



- Flexigrobots-h2020.eu
- FlexiGroBots
- Flexigrobots
- YouTube



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

During the last months of the project, significant efforts were made in the realm of **artificial intelligence (AI) standardization**, especially within the framework of the **European Open Science Cloud (EOSC)**. Several initiatives were explored to establish standardized practices for AI, aiming to enhance collaboration and data sharing across diverse research projects.

A crucial focus during this period was the analysis of Flexigrobots Data Management Plan. Comprehensive evaluations were conducted to ensure effective handling, storage, and sharing of research data. Emphasis was placed on refining existing plans and developing new strategies to optimize data management and interoperability. This initiative aimed to **enhance the quality of data** available for research purposes, making it more accessible and usable for scientists and researchers within the community.

Additionally, efforts were directed toward exploring various data products with the objective of improving their interoperability. By analyzing different data formats, structures, and sources, the goal was to identify common ground and establish protocols that would enable seamless integration and exchange of data. This exploration was vital for fostering collaboration between diverse research communities, ensuring that data-driven insights could be effectively shared and utilized across disciplines.

Overall, these actions presents a significant step forward in the EOSC's mission to **promote standardized practices in AI**, **enhance data management capabilities**, and **facilitate**

better interoperability of data products. These initiatives underscore the commitment to creating a robust and collaborative environment where researchers can harness the power of AI and data analytics to advance scientific knowledge and innovation.

WP3 – Platform development

As introduced in the previous newsletters, one of the main goals of FlexiGroBots is to **build an AI platform** specifically designed **to control different types of robots**. Over the past 6 months, a lot of work has gone into making the platform bigger and better. The platform now connects smoothly with parts from other teams, and everything has been updated to the latest versions. One of the big tasks was making sure all parts of the AI platform work well together.

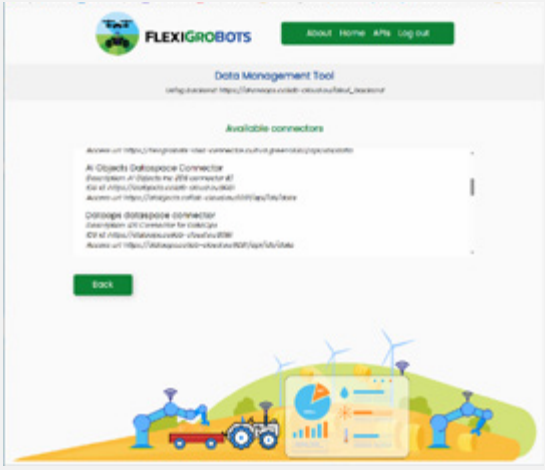
AI platform

The **AI platform** has been the tool used during the project to train and deploy AI models in real production environments. During this last period, the efforts of the AI platform have been focused on two branches. The first one is to integrate the AI platform with the rest of the project's architectures; this step is of vital importance to avoid the isolation of systems in the project and increase their utility. To achieve this, a component called **MQTT broker** has been incorporated, allowing communication with the different robots of the system through the MQTT protocol. The second branch has been the improvement and incorporation of hardware enhancements to increase the resources of the cluster, making the platform more robust in abnormal situations. Additionally, GPUs have also been added to run more models simultaneously and in a faster and more powerful way.

Data Space

As for the **Data Space**, it is designed to be secure and follows IDSA rules. It is now **fully connected to the AI platform**. Connectors have also been set up so that everyone in the project can use them. Furthermore, for data exchange with the AI platform, a **REST API** has been designed to interact with the data space more smoothly through online requests, which have been configured in a Jupyter notebook for easy use of the IDSA connector.

A **new element** in the FlexiGroBots data space is a **user interface** that can integrated into data space members, i.e. pilot partners



system. The UI provides simple mechanisms for sharing and browsing data in data space. The UI consists of a web application and a server backend that provides an interface between partner's systems and IDSA data space connector.

Geospatial enablers and service

Concerning FlexiGroBots geospatial enablers and services, Atos' team has paid particular attention in the last months to **integrating the Open Data Cube (ODC) instance with the MinIO service,** which provides a horizontal S3 storage layer for all components in FlexiGroBots architecture. With this change duplication of data is avoided, given that the ODC can now directly access to the UAV imagery collected by Pilot 1's drones as well as generate and index the STAC metadata as soon as new datasets are made available in the S3 storage (in the past, a copy of the data had to be made in the VM hosting the ODC component).

About the FlexiGroBots geospatial tools, there's ongoing work to make them connect better with the Data Svpace. This is important because the Data Space is where data is shared. All the geospatial tools can be found and used at *https://geo.flexigrobots-h2020.eu*.

Common apps

Regarding to the development of the **Common Applications**, having definitely reached the final phase of the project and with the applications clearly defined in the previous newsletter, the focus is now on the validation process. This process is carried out with a specific emphasis on extracting metrics. In addition, models improvements are also being made, based on the extra data collected during the last summer campaign.

In particular, a major effort has been made to adapt the air situational awareness model, with the aim of optimising its performance in the three pilots of the project. Similarly, the introduction of a more innovative model has been undertaken to reinforce **insect detection**, allowing more precise monitoring of the evolution of pests.

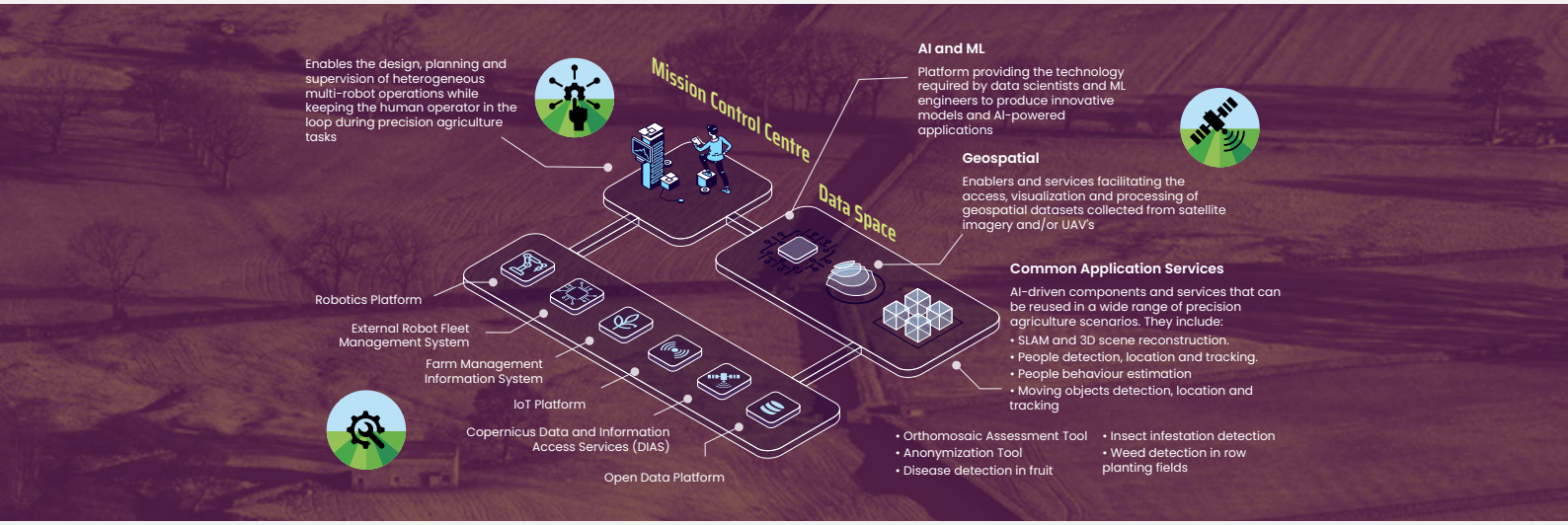
All applications are now available to consortium members, have been evaluated with real data and are in the final stages of validation.

The work carried out on this set of tools and services reinforces, once again, the commitment to offer effective and cutting-edge solutions to the challenges of modern agriculture. Furthermore, the continuous integration on a web platform that communicates in real time with the AI platform ensures an enhanced user experience and seamless access to AI functionalities.

Mission Control Center

The **Mission Control Centre (MCC)** serves as the command center for the FlexiGroBots platform, directing and overseeing all the robots. It's responsible for determining and assigning tasks to each robot. Recently, a user-friendly application, Fleet Manager, was introduced, simplifying the process of managing robot tasks. The Fleet Manager and the robotic systems participating the field mission communicate with MCC messages and MQTT broker. The Fleet Manager was tested in summer campaigns.

Another crucial data exchange aspect of the MCC is its communication with the Data Space, a comprehensive distributed information repository. Since the previous release of MCC the MCC capabilities to interact with a Data Space have been improved by adding features to create and update the data assets into Data Space directly from MCC mission workflow manager tool. With recent enhancements and ongoing developments, the MCC is continually evolving, aiming to provide efficient robot management in the agricultural sector.



WP4 – Pilot 1: Grapevines

Pilot 1 wants to **improve grape production** by **reducing the use of phytosanitary products**, as well as **help grape harvesters** in the field.

We completed the development of the **Decision Support Systems (DSS).** It allows the farmer to visualize, through a satellite view, data obtained from UGV inspection, via representing the telemetry received by the UGVs and the maps of Botrytis detection points generated after the ground inspection and detection of the AI platform. To visualize the detection of the disease, the results of the Botrytis detection AI algorithm are collected, and the information is integrated with the geospatial services, providing a layer with the points where the disease was detected. In addition, images taken by the UGVs of the plants affected by Botrytis can be visualized on the platform.

The Botrytis detection map guides the UGV for treatment. AI results inform the route plan sent to the UGV locations to travel and treat the bunches affected by the disease. We have developed a Cartesian robotic arm that allows

the UGV to approach the grape clusters to apply treatments with precision.

We improved DSS-UGV communication via MQTT FlexiGroBots Broker for harvest assistance. Platform tracks UGV location, harvest route, and scale weight.

In the middle of September, the field tests and the final demonstration of the harvesting assistance were carried out. A competitive trial was carried out to compare the time and quantity of grapes picked by harvesters with and without the assistance of the harvesting robots. There

[Pilot 1 Demonstrator integration, testing and deployments]

WP5 – Pilot 2: Rapeseeds

FlexiGroBots' second pilot, focusing on **Rapeseed and silage**, aimed to showcase a scenario **featuring multiple drones and robots** from various owners collaborating under a single fleet manager.

This demonstration encompassed the **development of diverse robots**, **mission workflow management,** the **coordination of a diverse robot fleet**, **integration with AI services** from the FlexiGroBots platform, and **data sharing** with the IDSA agriculture data space, all of which have been ongoing over the past three years.

We devised a **grassland renewal scenario**. Weeding robots eliminated Rumex weeds, ground robots managed fertilization and weed transport tasks via ISOBUS tasks and controllers, while autonomous drones oversaw seeding and supervision duties. These activities relied on drone surveys and AI image analyses. FlexiGroBots Mission Control Centre (MCC) Fleet Manager software supervised and controlled all devices. Multi-vendor and multi-party collaboration were enabled through MCC Mission workflow management and data exchange via FlexiGroBots agriculture data space. The scenario underwent validation at our Ruukki pilot site in northern Finland.

[Pilot 2 Demonstrator integration, testing and deployments]

WP6 – Pilot 3: Blueberries

It's been almost 3 years since the beginning of the project and our **agricultural robot Gari** has grown up. He **runs through the blueberry fields**, **collects the data** and **sprays the weeds**, substituting multiple field workers. This summer, we tested the whole system for field scanning using **UAVs** and **soil analysis** on the go. Getting out of the lab was indeed tricky, as fields can be muddy and slippery, but the navigation system proved to be very robust. This means that farmers can lay back, get rapid soil analyses, spray the weeds and optimise their decisions. Our image processing algorithms proved to be very effective.

Pilot 3 objectives, requirements and design

From the UGV perspective, the **robot can detect weeds** on the ridges in which the plants grow, while the **UAVs can successfully detect plant rows**, **perform zone delineation** and **infer chemical content of the crops**. This is possible through deep learning algorithms and meticulous processing of hyperspectral data, while the nutrient maps allow for high-accuracy **yield prediction** and provide actionable insights for the farmer. UGV-based crop health assessment using the **Plant-o-Meter** device was the last use-case to be implemented. It provided a crucial layer of data on top of the "layer cake" of soil and plant chemical properties for a deep analysis of plants and optimal decision-making. This use case was also successfully tested in vineyards, thus proving the scalability potential of Gari and his winged colleagues.

Pilot 3 Demonstrator integration, testing and deployments

WP7 – Dissemination and Exploitation

Over the last half-year of the project (M31-M36), WP7 has diligently executed its tasks in alignment with the proposed timeline and work plan. T7.1 and T7.2 have persistently advanced the project's promotional activities, leading to ongoing efforts in preparing and submitting scientific publications and organizing and participating in workshops. Several blog posts were published as well as 5th newsletter sharing ongoing activities and promoting project achievements.

The project made significant advancements in refining the business modeling, ecosystem building, and technology transfer components. The T7.3 leader successfully crafted comprehensive Guidelines and Templates for PESTEL and SWOT analyses. These tools offer a systematic approach to evaluating external macro-environmental factors and internal strengths, weaknesses, opportunities, and threats. Additionally, the project created Guidelines and Templates for the Business Canvas, an effective tool for

visualizing and defining the business model.

Nearing project's tech completion, focus shifts to business and tech commercialization for long-term viability. Consortium actively transfers tech to industry, tech developers, and ag/robotics Digital Innovation Hubs (DIHs). Three virtual farm days engaged 110 stakeholders, featuring critical tech components and the FlexiGroBots platform in real-life scenarios. Non-technical approach for diverse audience; Q&A sessions for engagement. Achieved KPIs in three demos.

The commencement of T7.5, focusing on Sustainability and long-term operations, took place in this reporting period. This initiative began in the project's 25th month, facilitating communication and discussions among members of various organizations involved in the task. The primary objective of this task is to formulate a plan ensuring the project's sustained viability over the long term. As part of these engagements, a concise presentation and a set of forms are being crafted to function as tools for gathering feedback from the digital innovation hubs.

The T7.6 task, titled "Ethical assessment of AI and Agrifood," represents, in part, a continuation of CEPS' examination of the ELSE factors, with an emphasis on expanding them for the ultimate development of a trustworthy AI model for precision agriculture. The most intricate aspect of this task is dedicated to investigating the ideal agri-food data spaces that can support trustworthy AI applications in precision agriculture.

News & Events

Drones – EU Projects Synergies

25/06/2023 | VILNIUS, LITHUANIA

FlexiGroBots partnet The Spanish National Research Council **CSIC** attended the "Startup Village Networking EVENT„ where they were invited to present CSIC developments in the FlexiGroBots project.

The 14th European Conference on Precision Agriculture ECPA 2023

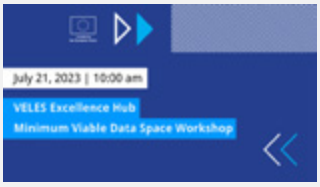
2 - 6/07/2023 | BOLOGNA, ITALY

The 14th European Conference on Precision Agriculture exhibited the results of ongoing research and applications in precision agriculture. **WU** & **CSIC** partners present research done within the scope of the FlexiGroBots project.

OKRA

5 - 8/07/2023 | Oripää, FINLAND

OKRA , one of Finland's largest agricultural fairs, assembles hundreds of exhibitors and thousands of visitors. **Mikko Hakojärvi** presented FlexiGroBots activities for interested customers in Mtech Digital Solutions booth.



VELES Excellence Hub | Minimum Viable Data Space Workshop

21/07/2023 | ONLINE

Carlos Cob from **ATOS** participated in this event as a speaker to introduce FlexiGroBots to the audience and, more specifically, to describe his experience implementing (and further extending) a Minimum Viable Data Space in the context of the project.

The 17th International Symposium on Operations Research in Slovenia

20 - 22/09/2023 | BLED, SLOVENIA

'SOR' stands as the foremost scientific event in the realm of operations research, part of the established series of biennial international conferences. **BIO** partners presented some of the results from the FlexiGroBots project at The 5th Precognition workshop that was organized within the conference.

Beyond nice words: Standardising Trustworthy AI

11/10/2023 | BRUSSELS, BELGIUM

Organized by **CEPS**, this event as part of the three-year FlexiGroBots project, highlights the establishment of standards to support the AI Act's implementation.

KoneAgria

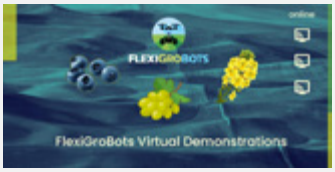
12 - 14/10/2023 | TAMPERE, FINLAND

KoneAgria is a meeting place for professionals in the agriculture and forestry industries where **Mikko Hakojärvi** presented FlexiGroBots activities for interested customers in **Mtech Digital Solutions** booth

European Big Data Value Forum

25 - 27/10/2023 | VALENCIA, SPAIN

IDSA organized a session „Unlocking Interoperability: The Dataspace Protocol in Research Projects and Sustainability via Open-Source Ecosystems" in EBDVF to disseminate the technical interoperability challenges identified in the FlexiGroBots project and invited data space experts to provide inputs on how these challenges could be tackled.

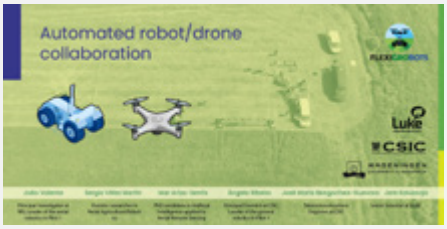


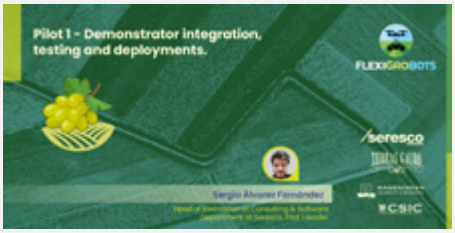
FlexiGroBots Virtual Demonstrations

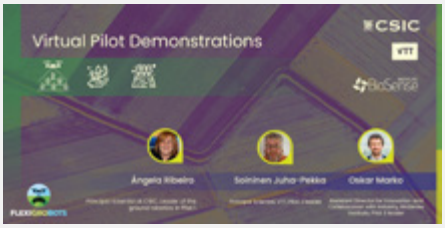
19 - 23/10/2023 | ONLINE

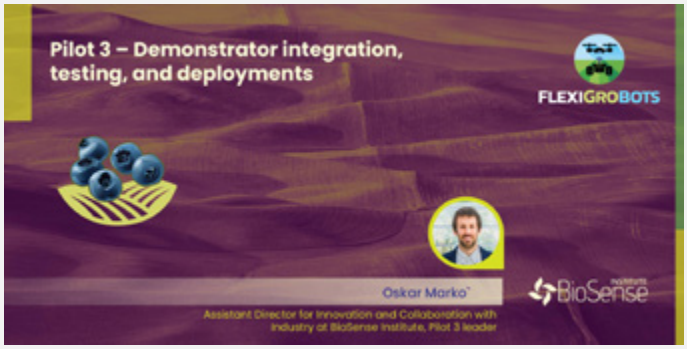
The FlexiGroBots Virtual Demonstration is an online event aimed at showcasing the latest technologies developed and utilized within our pilot project. One of the key goals of this event is to facilitate the transfer of these technologies from our project consortium partners to relevant partners in the fields of industry, technology development, and agriculture.

Blog









Publications

Detección y seguimiento de racimos para fenotipado en vídeos laterales de dron

Article

Mar Ariza-Sentis, Sergio Vélez, Hilmy Baja, João Valente

Non-scientific article: Partners from Wageningen University (WU) have published a non-scientific article that has explained how Grape Bunch Detection and Tracking is performed with videos acquired with UAVs to extract phenotypic traits.

Research article: Comparing Nadir and Oblique Thermal Imagery in UAV-Based 3D Crop Water Stress Index Applications for Precision Viticulture with LiDAR Validation

Article

Paper

Thomas Buunk, Sergio Vélez, Mar Ariza-Sentís, João Valente

FlexiGroBots partners from Wageningen University (WU) successfully published a new research article entitled “Comparing Nadir and Oblique Thermal Imagery in UAV-Based 3D Crop Water Stress Index Applications for Precision Viticulture with LiDAR Validation” in the Sensors

Research article: VineLiDAR: High-resolution UAV-LiDAR vineyard dataset acquired over two years in northern Spain

Article

Paper

Sergio Vélez, Mar Ariza-Sentís, João Valente

FlexiGroBots partners from Wageningen University (WU) successfully published a new research article entitled “VineLiDAR: High-resolution UAV-LiDAR vineyard dataset acquired over two years in northern Spain” in the Data in Brief.

Research article: BBR: An open-source standard workflow based on biophysical crop parameters for automatic Botrytis cinerea assessment in vineyards

Article

Paper

Mar Ariza-Sentís, Sergio Vélez, João Valente

FlexiGroBots partners from Wageningen University (WU) successfully published a new research article entitled " BBR: An open-source standard workflow based on biophysical crop parameters for automatic Botrytis cinerea assessment in vineyards" in the SoftwareX

Research article: Object detection and tracking on UAV RGB videos for early extraction of grape phenotypic traits

Paper

Mar Ariza-Sentís, Hilmy Baja, Sergio Vélez, João Valente

FlexiGroBots partners from Wageningen University (WU) successfully published a new research article entitled "Object detection and tracking on UAV RGB videos for early extraction of grape phenotypic traits" in the Computers and Electronics in Agriculture.phenotypic traits" in the Computers and Electronics in Agriculture.

Meet FlexiGroBots Partners

Bodegas Terras Gauda

Bodegas Terras Gauda was founded in 1990 to produce white wines with native grape varieties under DO (Appellation of Origin) Rías Baixas. The DO Rias Baixas currently has more than 200 wineries, among which TERRAS, as a SME private company, is the number one in volume and annual turnover.

Since 1990, Terras planted their vineyards, always with the clear idea of safeguarding the identity of the O Rosal Valley wine. Therefore, we not only planted the renowned Albariño variety, but also Caiño Blanco and Loureiro.

Terras currently farms around 120 ha of vineyards and in this one, we have different plantation frameworks, as well as vineyards located on gentle slopes, on plains or on steep slopes, which makes it very interesting as a use case in FLEXIGROBOTS Project.

In addition to its participation in numerous R&D&i national projects, Terras has experience in participating in European projects, which provides strength to our presence in FlexiGroBots.

Terras has a staff of 55 people who have professional skills not only to achieve excellent quality in our vineyard and in our wines, but to contribute with their knowledge to the development of R&D&I projects.

Terras Gauda is participating as a consortium partner in the FlexiGroBots project in Pilot 4 on vineyards and, of course, as an end user. We are carrying out the different use cases developed in Pilot 4. To do this, we have selected specific plots for each of them, with different grape varieties, slopes and conditions.

Emilio Rodríguez Canas
Winemaker, Technical and R&D Director of TERRAS.

Enrique Costas Rodríguez
CEO of the TERRAS group.

Ana Oliveira Ortega
Specialist Technician in production at TERRAS.

terrasgauda.com
@TerrasGauda
grupo-terras-gauda

AgroSmart SIA

AgroSmart SIA is an AgriFood technology focused SME from Latvia. The company is developing, implementing and providing farmers and the wider agriculture industry with efficient, sustainable and innovative ICT solutions. The company has expertise in such technology domains as sustainable and precision agriculture, data management and resource planning, data analysis and machine learning, sensor and robotic solution integration, system interoperability, remote sensing solution utilization, etc.

Agrosmart will be leveraging its experience in facilitating international agrifood technology transfer and collaborate on demonstrator integration, testing, deployment, and assessment under the organization and implementation of Pilot 3 on blueberries monitoring.

Involved person: *Linas Didžiulevčius*

tagrosmart.lt
silosagrosmart

AgriFood Lithuania DIH

AgriFood Lithuania DIH is a non-profit cluster organization established since 2011 in Vilnius, Lithuania. AFL brings together major research, business and public stakeholders in Lithuania for the common mission of transforming agriculture, food and associated sectors with digital-based innovations. AFL links its stakeholders with international and cross-sectorial initiatives, provides all-round dedicated support in the research, development and deployment of agri-food innovations, and fosters the competence and capacity growth of the innovation ecosystem in general.

The cluster is also operating as a Digital Innovation Hub (DIH) and has been acknowledged by the EC Joint Research Centre as an example DIH with excellence in sectoral specialization. Together with a consortium of national partners, AFL has been selected as one of Lithuania's European Digital Innovation Hubs. AFL is responsible for the development of the business modeling and ecosystem building as well as contributes to Pilot 3 on blueberries monitoring.

Involved person: *Kęstutis Skridaila*

hackagrifood.lt
@AgriFoodDIH_LTU
agrifood-lithuania-dih

FLEXIGROBOTS

Flexigrobots-h2020.eu
FlexiGroBots
Flexigrobots
YouTube

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