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Autonomous UAV and UGV conductive charging system with a robotic arm and an optical sensor aimed at vineyard monitoring

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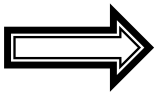
Greece 2.0 NATIONAL RECOVERY AND RESILIENCE PLAN
Funded by the European Union NextGenerationEU

Introduction – General

> 8 b (2022)

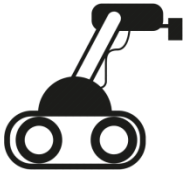


BUT
- Climate change
- Labor shortage
- Performance costs

Smart Farming Technologies

- Farm Management Information Systems (FMIS)
- Precision Agriculture Systems
- Agricultural Automations and Robotic Applications

(a) Yield increase
(b) Product quality improvement
(c) Efficient use of inputs
(d) Energy use reduction
(e) Soil and water resources protection



As **individual solutions** rather than as a combined system where the two vehicles assist each other

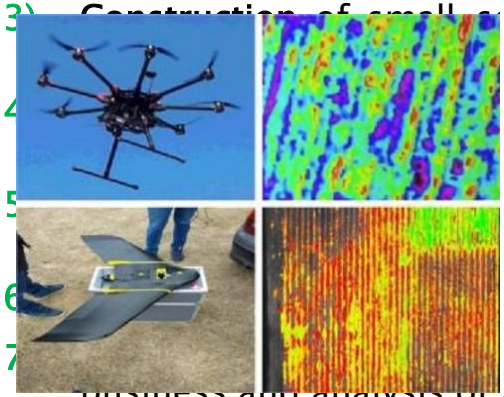
Introduction – Main objective of Project AgroSYS

- Development of an **integrated autonomous precision viticulture system** based on the actions of electric UAVs and UGVs
- Fleet vehicles will be **charged at solar charging stations** placed within the vineyard, incorporating technologies to **monitor vigor and volume of the vines**, as well as technologies to **measure water stress** for irrigation scheduling and **yield maturity assessment** for selective harvesting

Introduction – Specific objectives

1) **Establishment** of a combinatorial sensing system for vineyards using UAVs' and UGVs' sensors and decision-making for agricultural practices (irrigation, fertilization, selective harvesting)
2) **Development** of a safe navigation system for UAV/UGV fleet operating in vineyards by integrating appropriate sensors in the vehicles and algorithms to identify and avoid obstacles
3) **Construction** of small-scale [illegible] UAV and UGV that will be
4) [illegible] g
5) [illegible] d
6) [illegible]
7) [illegible] l

business and analysis of the results for commercial exploitation of the system



Introduction – Conductive charging system

- The current process of charging electric unmanned aerial and ground vehicles (UAVs and UGVs) for farming use is time-consuming and lacks automation
- Typically, the battery must be manually removed from the vehicle, charged separately and then reinstalled, which significantly reduces operational efficiency and requires human intervention
- Inductive charging systems as an alternative -> Charging time?

skyrc.com

clearpathrobotics.com

wibotic.com

Materials and Methods

- The system involves modifying the existing battery-vehicle interface to integrate a **universal plug** that allows for easy connection to the charger through the robotic arm
- Unmanned Vehicles:
  - UAVs: 2x DJI-S1000
  - UGV #1: Husky by Clearpath Robotics
  - UGV #2: Thorvald platform by Saga Robotics

Materials and Methods

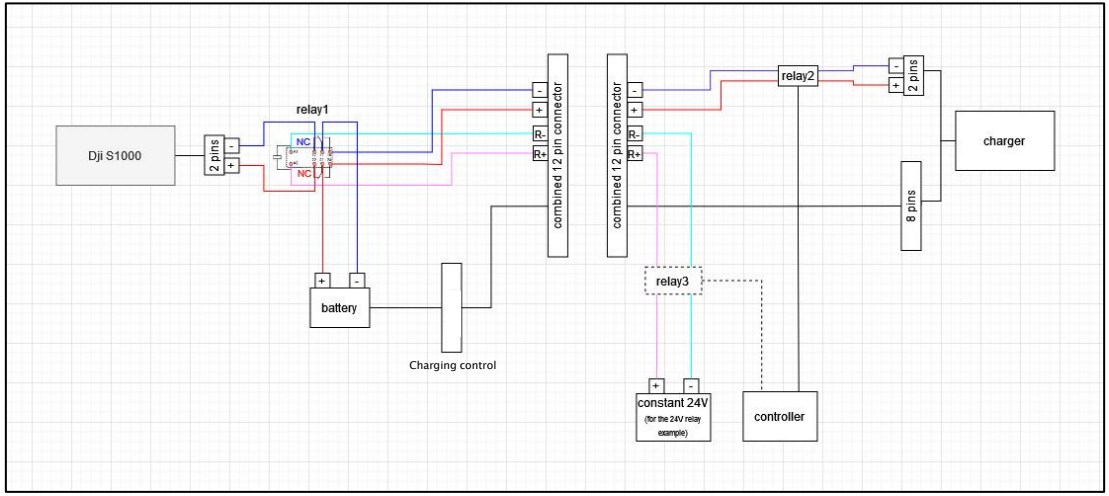
Plugs' installation prerequisites

- Installed on a **visible position on the upper side** and oriented vertically upwards
- **Securely mounted** on a solid surface
- Battery should be **disconnected from the vehicle before** the initiation of the charging process
- UAVs: Should barely modify the frame in order to **not disrupt the flying ability**
- UGVs: Robotic arms should be **able to charge both UGVs** bearing the same plug – wiring issue
- UGVs: Plugs should be placed in the **front part of the UGVs** in the direction of travel in order to be accessible from the arms (due to the limited working range of the arms / limited space within the charging stations)

Materials and Methods

Wiring diagrams

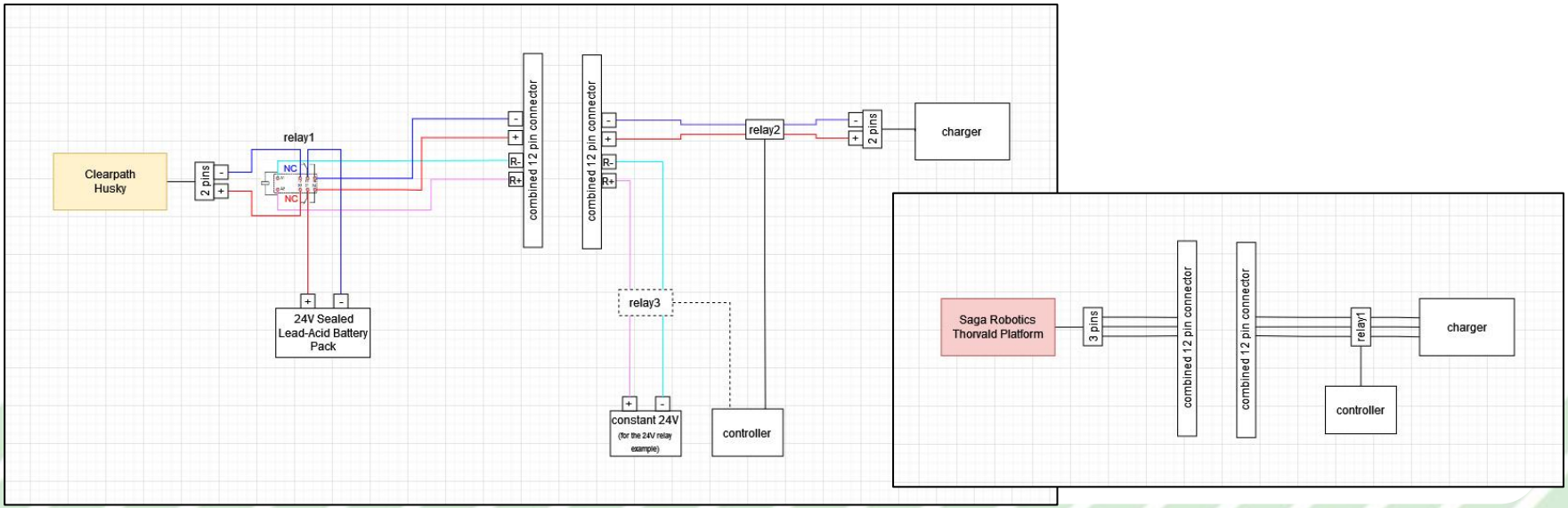
- **relay #1:** disconnect the vehicle from the battery *(NC – normally closed during flight)*
- **relay #2:** connect the charger to the vehicle through the **relay#1**
- **relay #3:** to control the **relay#1**



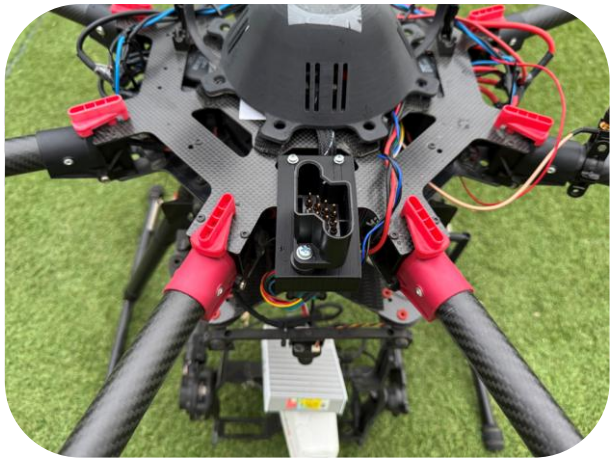
Materials and Methods

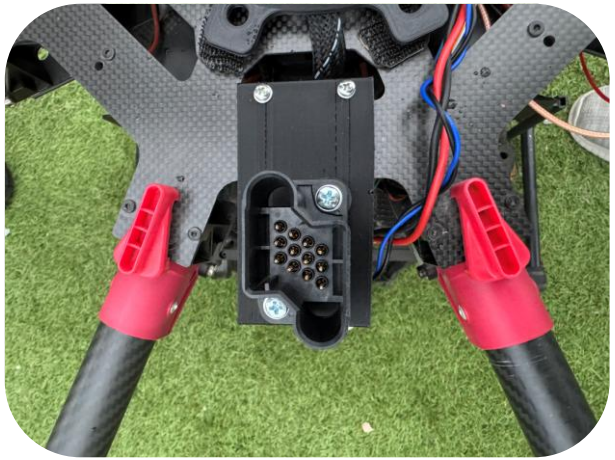
Wiring diagrams

- Respectively for the **Husky** and the **Thorvald platform**
- Currently testing with the same 12-pin plug even if they do not utilize a LiPO battery

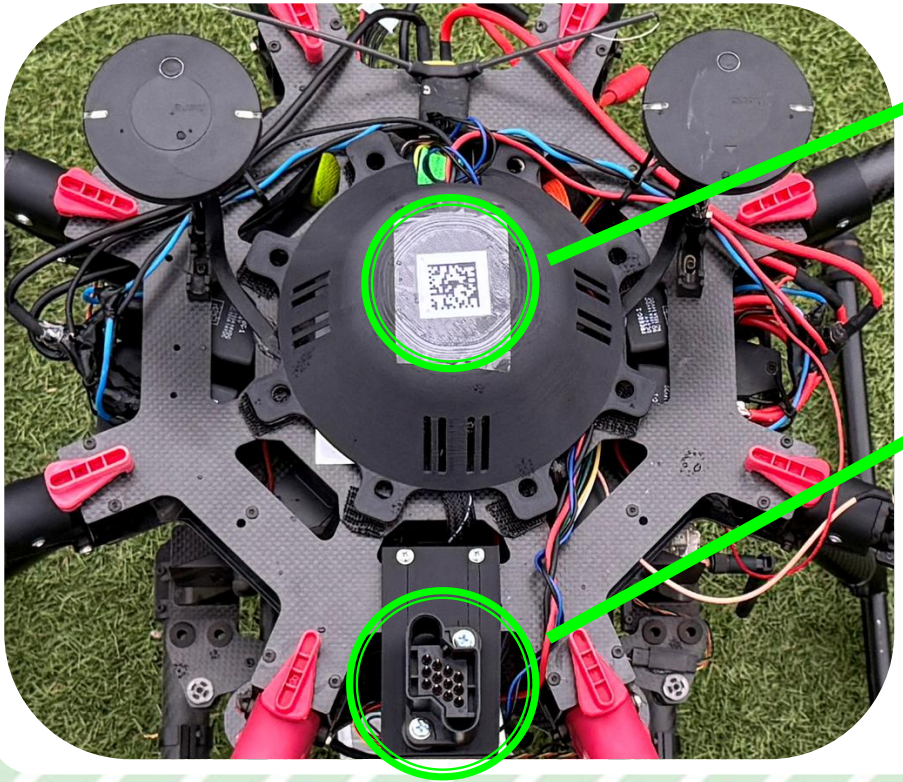


Materials and Methods





Materials and Methods



Data matrix to be detected by the optical sensor on the arm

& according to its position/orientation locate the plug

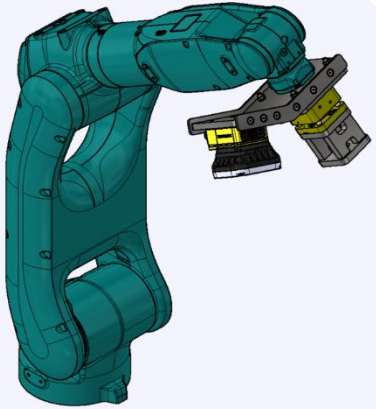
12-pin Plug 211759-1 by TE Connectivity

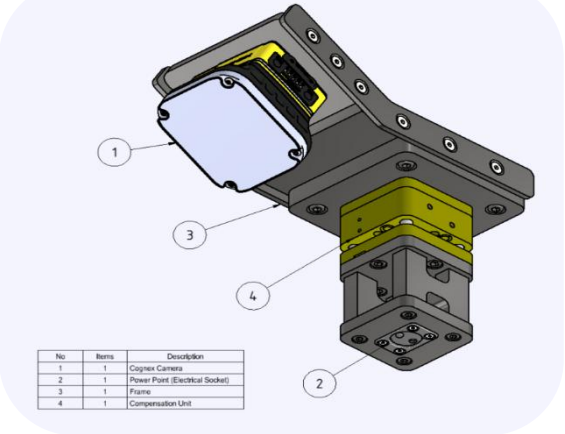
mounted on a specially designed base

paired by 211758-1 on the robotic arm

Materials and Methods

- A robotic arm equipped with an optical sensor detects and aligns the universal plug with the charging port on the vehicle and initiates the charging sequence
  - Robotic arm #1: Cobot HC10DTP by Yaskawa Europe GmbH
  - Robotic arm #2: MOTOMAN GP7 by Yaskawa Europe GmbH
  - Optical sensor by Cognex





No	Items	Description
1	1	Cognex Camera
2	1	Power Point (Electrical Socket)
3	1	Frame
4	1	Compensation Unit

Materials and Methods

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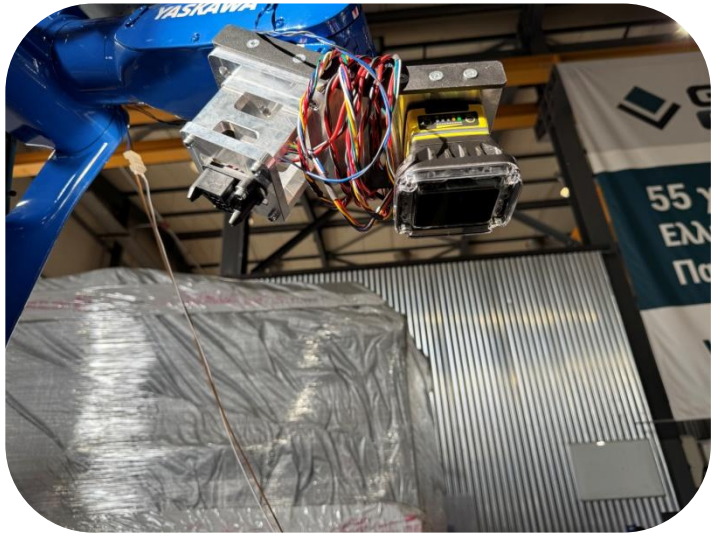

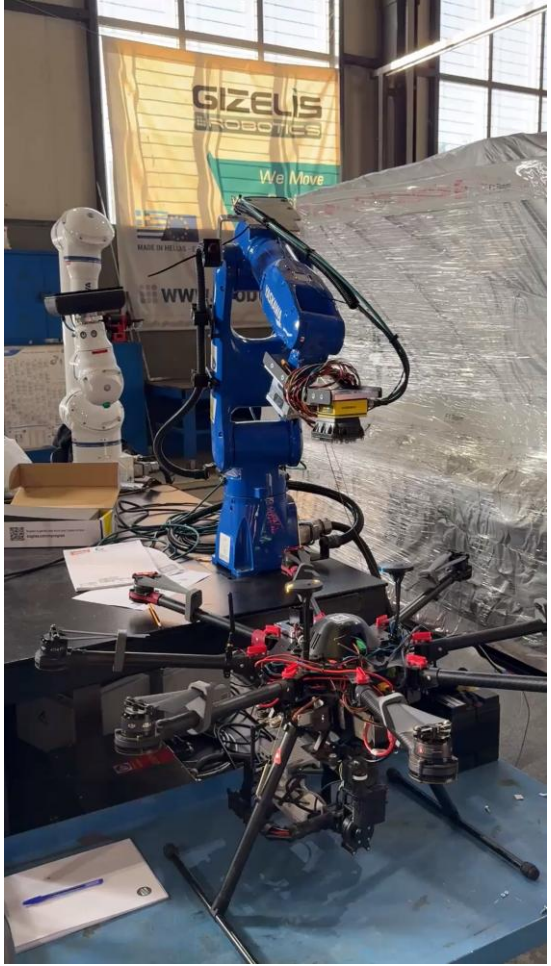
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ROBOTICS
We Move

Results

- The mounting of the plugs on a robust surface on the UAVs **was a challenge**, in contrast to **the UGVs that offer enough space and robust surfaces** for the plugs to be mounted
- The system **does not interfere with the flight operation** of the UAVs – the UAVs operate normally as intended
- The optical sensor **successfully detects the data matrix and aligns the plugs** with precision
- The plugs are being successfully attached but some **strain has been observed on the UAV** frame during the pin attachment – magnetic plugs to be tested
- The **battery is being successfully isolated** from the vehicle circuit, either automatically or manually through the controller
- The charging sequence starts and stops as intended

Conclusions & Next steps

Conclusions

- Successfully **eliminates the need for human intervention** in the charging process
- **Reduces downtime** thus allowing for longer periods of crop monitoring within a given time frame
- Enables **fast and efficient conductive charging** for UAVs and UGVs, reducing the time spent on manual battery handling
- Presents a **significant advancement in electric vehicle charging technology for agriculture**, supporting more efficient and scalable operations in precision farming

Next steps:

- Final installation and tests on both types of UGVs
- Integration with and on-site testing of the complete AgroSYS system
- Efficiency comparisons with induction charging systems

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AgroSys Project

www.agrosys-project.gr

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