Funded by the European Union

Marie Skłodowska-Curie Actions

Green Field Data

Exceptional
36-months Double Degree PhD Scholarship

Cotutelle PhD degree, Engineering Sciences and Technology from ULB and Engineering Sciences - Perception and Robotics from UCA

Adaptive Navigation for Agricultural Robots using Database-Driven Insights

EU Recruiting institutions	Université Libre de Bruxelles, Dept. of Computer and Decision Eng., Data Science and Engineering Lab, Belgium (18 Months) TSCF research unit, Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement (INRAE), Clermont-Ferrand, France (18 months)
Keywords	Foundation Models, Databases, Trajectory Planning, Autonomous agricultural robots, Navigation

Exceptional benefits at a glance

- ***International PhD training excellence (here)***
- ***Renowned supervisors & top-tier labs***
- ***Interdisciplinary & multi sectoral research***
- ***Competitive MSCA salary & allowances***
- ***Global academic & industrial network***
- ***Non-academic secondments***

Salary

Living Allowance	Mobility Allowance*	Family Allowance**
Gross amount		
EUR 4010	**EUR 710**	**EUR 660**

Long Term leave allowance (if applicable)

Special needs allowance (if applicable)

*private mobility-related costs (e.g. travel and accommodation costs), not their professional costs under the action

**doctoral candidate has or acquires family obligations during the action duration, i.e. persons linked to him/her by (i) marriage, or (ii) a relationship with equivalent status to a marriage recognised by the legislation of the country or region where this relationship was formalised; or (iii) dependent children who are actually being maintained by the researcher, the family allowance must be paid to him/her as well

GreenFieldData Project at glance

This doctoral position is 1 of 14 double degree doctoral positions offered within the HORIZON Marie Sklodowska-Curie Action (MSCA) Joint Doctoral Network GreenFieldData : "IoRT Data management and analysis for Sustainable Agriculture. **GreenFieldData** will train a new generation of researchers able to tackle digital and green transition challenges using a human-centric approach to ensure the robustness and relevance of the solutions responding to the specific needs of the EU market in a context of climate change and increasing socio-economic constraints. At a policy level,

GreenFieldData outcomes will feed in directly to the aims of the HE Strategic Plan 2025-2027, EU Partnership Agriculture of Data and Digital EU Program. **GreenFieldData** proposes a high-level interdisciplinary, inter-sectoral and international (triple 'i') research project and training network on new IoRT (Internet of Robotic Things) based solutions for sustainable agriculture. **GreenFieldData** will mobilize 14 Doctoral Candidates (DCs) enrolled in Double Degree Doctorate programmes with 12 academic main beneficiary partners, across 7 EU countries. Moreover, 21 non-academic associated partners, and 3 academic associated partners will provide support to the DCs. The partners form a high quality network, where Academic partners have previous research collaborations as outlined in a common vision paper. The ambitious project will provide the DCs with a unique toolbox of cutting-edge knowledge, tools and strategies which will boost their employability and benefit the next generation operational workforce (researchers, Digital Technologies (DTs) and agricultural stakeholders). The project results will also benefit EU innovation as the human-centric IoT devices & robotics, and data-based solutions tailored to EU context will enable the agricultural sector to assess and mitigate the impacts of climate change, and define new sustainable low input practices, thus increasing resilience and competitiveness.

PhD Project O – Adaptive Navigation for Agricultural Robots using Database-Driven Insights

Context: An agricultural robot is an unmanned ground vehicle UGV equipped with sensors and actuators and able to safely and autonomously perform one or several tasks on a farm field. Such a robot is composed of a locomotion part connected to a navigation system, and an agricultural part with either mounted, semi-mounted, or towed implements.

An agricultural robot can be designed to perform a specific task (e.g., weeding or harvesting) or it can be used as a tool carrier offering various equipment combinations (tillage, seeding, fertilizing, etc.). The world population growth is increasing the demand for sustainable healthy farming production. To satisfy this need, agro-ecology aims at developing new cultural practices leading to an environment-friendly farming production.

When a mobile platform moves autonomously, it must perform a variety of tasks, including localization, route planning, motion control, and mapping, which is a critical stage in autonomous operations. These robots move following as much as possible a predefined trajectory, and they try to avoid obstacles and respect the planned timing. Nowadays, this predefined trajectory is manually defined by farmers or created by applying topological algorithms that maximize the spatial covering of the worked plot. Therefore, this spatial planification of the trajectory does not take into account the real life conditions including environmental factors, soil conditions, natural obstacles, mechanical failures, field humidity, and other variables that impact the real behavior of the robots and thus their actual trajectory. Moreover, the planned trajectory is not adapted in real time to these real life conditions. Robots do not adjust their behavior when the spatio-temporal conditions change.

Data involved in enabling the robot to make such autonomous deviations should be:

- Real-time sensors data, e.g., air temperature, wind speed, produced at hour frequency.
- Real-time odometry data, i.e., data from motion sensors to estimate the changes in the robot's position over time, produced at ms or second frequency.
- Real-time alert data related for instance to mechanical faults of robots or to delays in the

planned task, produced at an episodic frequency.
- Spatial and attribute data representing contextual information, such as the geometries of the plots, the pre-planned trajectory, etc.
- Real-time LiDAR and image acquisitions for the field.
- Historical data on the past missions of the robot.

One researched approach to effectively handle these real-time adjustments is the point-to-point planning strategy. The objective is to identify an obstacle free route from the starting point to the destination point, aiming to minimize time, distance, and energy consumption. In the literature several approaches have been investigated including: genetic algorithms e.g., [1], A* shortest path e.g., [2], artificial potential field e.g., [3]. In general, research has been focused on formulating point-to-point planning as an optimization problem [5].

Objectives: In this thesis, we want to investigate point-to-point planning as a learning problem [4]. We consider that a robot has a history of operations in the same field under different weather and crop conditions. Point-to-point routing can thus be approached as a learning problem where the robot memorizes some representation of the trajectories that were successful in the past, the ones that failed, and combines this knowledge to autonomously plan its rerouting.

Therefore, there is a need to store the operations history (or some representation of it) [6,7,8] and be able to generate new rerouting decisions learned from the best trajectories the robots have done in plots. These parameters include the accumulated delay, the deviation from the predefined trajectory, the number of mechanical faults, soil compaction, etc. Therefore, it will be possible to find out the best way to work for each robot in each plot. These objectives will be achieved using the following work plan to grant their feasibility.

Work plan:

1. Define data engineering pipelines to prepare/validate the data of the history of operations for the learning.
1. Propose ways to successfully navigate agriculture robots in the field by using their past operations experience.
2. Define models for storing the past operations of a robot and investigate point-to-point planning as a learning problem, e.g., using foundation models for spatiotemporal trajectories or potentially also multi-modal.
3. Design interaction methods for involving human-in-the-loop to guide the robot navigation.

Expected Results

1. A spatiotemporal database system for operation history.
2. Models for generating re-routing decisions under varying conditions, based on learning.
3. A human-centric system prototype for real time navigation.
4. Interfaces for trajectory selection and task planning.

References

[1] Noguchi, N.; Terao, H. Path Planning of an Agricultural Mobile Robot by Neural Network and Genetic Algorithm. Comput. Electron. Agric. 1997, 18, 187–204

[2] Santos, L.; Santos, F.N.D.; Mendes, J.; Ferraz, N.; Lima, J.; Morais, R.; Costa, P. Path planning for automatic recharging system for steep-slope vineyard robots. In ROBOT 2017; Springer: Berlin/Heidelberg, Germany, 2018; pp. 261–272

[3] Yan, X.-T.; Bianco, A.; Niu, C.; Palazzetti, R.; Henry, G.; Li, Y.; Tubby, W.; Kisdi, A.; Irshad, R.; Sanders, S.; et al. The AgriRover: A Reinvented Mechatronic Platform from Space Robotics for Precision Farming. In Reinventing Mechatronics; Springer: Berlin/Heidelberg, Germany, 2020; pp.

55–73. ISBN 9783030291303.

[4] Gaspard Merten, Gilles Dejaegere, and Mahmoud Sakr. 2025. Building a Foundation Model for Trajectory from Scratch. In Proceedings of the 33rd ACM International Conference on Advances in Geographic Information Systems (SIGSPATIAL '25). ACM, New York, NY, USA, 421–431. https://doi.org/10.1145/3748636.3762765

[5] Sandro Bimonte, Gianni Bellocchi, François Pinet, Gérard Chalhoub, Mahmoud Sakr, and Piotr Skrzypczyński. 2025. Data engineering for sustainable agriculture: developments, challenges, and case studies of a novel IoRT architecture. Journal of Big Data 12, 1 (2025), 195.

[6] Gaspard Merten and Mahmoud Sakr. 2023. Brussels Mobility Twin (Data and Resources Paper). In SIGSPATIAL'23: Proceedings of the 31st ACM International Conference on Advances in Geographic Information Systems.

[7] Mohamed Mokbel, Mahmoud Sakr, Li Xiong, Andreas Züfle, Jussara Almeida, Taylor Anderson, Walid Aref, Gennady Andrienko, Natalia Andrienko, Yang Cao, and others. 2024. Mobility data science: Perspectives and challenges. ACM Transactions on Spatial Algorithms and Systems 10, 2 (2024), 1–35.

[8] Esteban Zimányi, Mahmoud Sakr, and Arthur Lesuisse. 2020. MobilityDB: A mobility database based on PostgreSQL and PostGIS. ACM Transactions on Database Systems (TODS) 45, 4 (2020), 1–42.

PRACTICAL INFORMATION

Recruiting and host institutions	• Université Libre de Bruxelles, Dept. of Computer and Decision Eng., Data Science and Engineering lab, Belgium (18 Months) • TSCF research unit, Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement (INRAE), Clermont-Ferrand, France (18 months)
Doctoral schools	• Ecole Polytechnique de Bruxelles @ Université Libre de Bruxelles, Belgium • École Doctorale des Sciences Pour l'Ingénieur (SPI) @ University Clermont Auvergne
Supervisors	• Prof. Mahmoud SAKR (University Libre de Bruxelles, Belgium) • Dr. Roland LENAIN (INRAE, Institut national de l'agriculture, de l'alimentation et de l'environnement) • Dr. Riccardo Bertoglio INRAE, Institut national de l'agriculture, de l'alimentation et de l'environnement)
Non-academic mentors	
Secondments	• Manitou Group, France, month 18 – month 20 , Industrial platforms & end-users requirements • Recyclo, Brussels, month 24 - month 27, routing

Contact information

- mahmoud.sakr@ulb.be

RECRUITMENT CRITERIA

General criteria

- MSCA Mobility Rule: researchers must not have resided or carried out their main activity (work, studies, etc.) in Belgium for more than 12 months in the 36 months immediately before their date of recruitment
- All researchers recruited in a DN must be doctoral candidates (i.e. not already in possession of a doctoral degree at the date of the recruitment)
- An applicant must have received the equivalent of 300 ECTS with a major in computer science, from which at least 120 ECTS corresponds to a master degree. The master degree must, in its original academic system, grant direct access to PhD programmes.
- Scientific excellence to fit the PhD project
- Fluent (oral and written) English skills as the project operates in English language
- Knowledge of the language of the host country may be considered a merit
- Team-mindedness

Required Skills

- Advanced artificial intelligence research skills, especially foundation models
- Advanced skills in data management, databases, and programming
- Interest in interdisciplinary collaboration across robotics, AI, and agricultural sciences
- Strong scientific writing skills, with the ability to synthesize research findings and produce high-quality scientific manuscripts.

APPLICATION

How to apply?

- **All information are provided here**

Deadline: 15th April 2026

Other information

About ULB and the Data Science and Engineering Lab

The Université libre de Bruxelles (ULB) is a truly multicultural institution, with one third of its students and researchers coming from abroad. International relations are part of everyday life at ULB, reflecting the spirit of Brussels itself, one of the world's most cosmopolitan cities. With four Nobel Prizes in the sciences, one Fields Medal and three Wolf Prizes, the Université libre de Bruxelles has a longstanding tradition of academic and research excellence. ULB is an active

member of the European Research Area and has received the EU's HR Excellence in Research award (EURAXESS), along with EU funding to support postdoctoral researchers through the COFUND programme. Over the past few years, ULB has secured 49 European Research Council (ERC) grants, including Starting, Consolidator, Advanced, Synergy and Proof of Concept awards supporting groundbreaking research in medicine, mathematics, political science, economics, physics and more. In addition, the University's Institute for European Studies is recognised as a "Jean Monnet European Research Centre" for its contributions to the study of European integration.
The Data Science and Engineering Lab (DSL) in the ULB has expertise in IoT, Geospatial, Mobility Data Science and in Open-Source system development. The research of the group covers the topics of mobility data AI, computational geometry, query processing, distributed databases, declarative query distribution, indexing, distance measures, and analysis primitives. The DSL lab has long expertise coordinating MSCA Joint Doctoral Networks: IT4BI-DC (2013-2020), DEDS (2021-2025), and Erasmus Mundus Joint Master: IT4BI (2011-2017), BDMA (2016-2026 – two back-to-back projects), DEAI (2025-2031), in addition to participating in the RIA projects EMERALDS (CL4-2022-DATA-01-05, RIA), and MobiSpaces (CL4-2021-DATA-01-01, RIA). Prof. Mahmoud Sakr (serving as co-supervisor of this thesis) has research focus in the domain of mobility data science and AI. He is co-creator of the MobilityDB open-source platform, the Brussels Mobility Twin open data platform, and the GeoPandas-AI open-source library, and co-chair of the OGC Moving Feature Standards Working Group. His previous organization roles include Co organizer of Dagstuhl seminar on Mobility Data Science, co-organizer of NII Shonan seminar on Mobility AI, general co-chair of IEEE MDM 2024 in Brussels and IEEE MDM 2025 in California. He is member of the FARI institute AI for the Common Good, Brussels.
More about your PhD in ULB: https://www.ulb.be/en/your-phd
More about the campus life and student facilities in ULB: https://www.ulb.be/en/campus-life

INRAE and TSCF research unit

INRAE. The French National Research Institute for Agriculture, Food and Environment (INRAE) is a public research institution bringing together a working community of 12,000 people, with 272 research, service, and experimental units located in 18 centers throughout France.
INRAE ranks among the world's leading institutions in agricultural and food sciences, and in plant and animal sciences. Its research aims to build solutions for multi-performing agriculture, quality food, and the sustainable management of resources and ecosystems.

TSCF. The 'Technologies and Information Systems for Agrosystems - Clermont-Ferrand' (TSCF) research unit employs 60 people and is based at 2 sites: the Pôle Scientifique et Universitaire des Cézeaux in Aubière (63) and the Site de Recherche et d'Expérimentation in Montoldre (03). The TSCF unit is dedicated to developing new technologies for agriculture, with a particular focus on agricultural and environmental robotics. The unit is equipped with facilities for developing mobile robots, especially for off-road applications. The unit has a fleet of eight robots, equipped with sensors, designed for various purposes and ranging in size from 10 kg to 6 tons. These robots feature either skid-steering or Ackermann steering configurations. The laboratory also has 80 hectares of experimental fields, along with facilities for assessing robot efficiency. For the past 15 years, the TSCF team has been actively working on robotics for agriculture, developing numerous algorithms to control robots in dynamic and changing environments. Their work includes applications such as trajectory following, pedestrian tracking, and edge following.

Your Quality of Life at INRAE

By joining INRAE, you benefit from (depending on the type and duration of your contract):

- Up to **30 days of paid leave** + **15 RTT** days per year (for a full-time position);
- **Parental support**: **CESU** for childcare, benefits for leisure activities;
- **Skill development schemes**: training, professional orientation counselling;

- **Social support**: advice and listening, social aid and loans;
- **Holiday and leisure benefits**: *chèque-vacances* (holiday vouchers), accommodation at preferential rates;
- **Sports and cultural activities**;
- **Collective catering** (cafeteria/canteen).

The Cézeaux site is served by Tram Line A, and is also equipped with parking and services dedicated to cycling.

Notes on terms:

- **RTT** (*Réduction du Temps de Travail*): Days off granted in compensation for working slightly more than the official legal working hours (a mechanism for reducing working time in France).
- **CESU** (*Chèque Emploi Service Universel*): A payment voucher/scheme in France used to pay for personal services, often including childcare. **CESU for childcare** refers to a specific pre-financed voucher for childcare expenses (usually for children aged 0-6).
- ***Chèque-vacances***: Government-subsidized holiday vouchers in France used to pay for travel, accommodation, and leisure activities during holidays.