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1. Scientific and professional profile and career

I am an Assistant Professor at the Faculty of Engineering of the University of Porto (FEUP) and Senior Researcher at INESC TEC, where I founded and lead TRIBE Lab and coordinate the TEC4AGRO-FOOD initiative. My research focuses on **field robotics for agriculture and forestry**, particularly autonomous systems capable of operating in complex, unstructured and challenging environments.

My scientific trajectory evolved from embedded systems, GNSS and autonomous vehicles towards integrated field robotics, combining robot design, localisation and navigation, perception, AI, sensing, IoT and intelligent implements. A defining feature of my career has been the translation of research into technologies validated under real operating conditions.

Since 2017, I have built TRIBE from a small research activity into a multidisciplinary team of 27 core researchers in 2025. I have attracted competitive European and national funding, participated in more than 40 funded projects and coordinated the €2.5M H2020 Innovation Action SCORPION. These activities generated scientific publications, open-source software and more than 20 prototypes above TRL5, including the WETA, Modular-E and Modular-X robots.

More recently, this trajectory has progressed towards large-scale deployment and exploitation through VineShield-DT, the approved ecoBOTs.pt initiative and, in 2026, the creation of **VIFIELD**, a spin-off designed to bring field-robotics technologies developed from this research ecosystem closer to market.

My career therefore combines **scientific excellence, research-team building and translation of knowledge into real-world impact**, connecting fundamental robotics research with agriculture, forestry, industry and society.

2. Contributions to science and society

2.a. Contributions to the generation of new ideas, tools, methodologies or knowledge

My main scientific contribution has been to advance **autonomous field robotics for agriculture and forestry**, addressing the challenge of enabling robots to operate reliably in natural environments characterised by uneven terrain, steep slopes, vegetation, changing appearance and limited GNSS availability. Rather than treating perception, localisation, planning and control independently, I have pursued a system-level research approach in which new algorithms are integrated into complete robots and validated under real operating conditions.

I first established a research line on reliable navigation in challenging agricultural environments. My work contributed methods for localisation and mapping, perception, path planning and collision avoidance, progressively addressing environments where GNSS alone is insufficient. This research generated, among other results, **VineSLAM**, a multi-layer localisation and mapping approach combining complementary

representations of agricultural environments, and **AgRob-PP**, a planning framework tailored to field robots. These tools evolved through successive research projects and became reusable components across different robotic platforms and applications.

I subsequently extended this work from individual algorithms to integrated and modular field-robotics systems. I led the scientific and technological trajectory from successive AgRob platforms to WETA, Modular-E and Modular-X. These platforms integrate electric mobility, embedded control, autonomous navigation, perception, safety and interchangeable implements, enabling the same robotic research infrastructure to address operations including vegetation management, precision spraying, fertilisation and, increasingly, pruning, harvesting and forestry operations. Modular-E reached TRL6 and was awarded second-best robot at FIRA 2024, while WETA received an iF Design Award.

SCORPION was a decisive step in demonstrating that this research could operate at European innovation-project scale. I initiated the proposal, assembled the consortium and coordinated this €2.5M H2020 Innovation Action. My team developed two robotic platforms and new approaches for localisation, slope-aware path planning and mission supervision for precision spraying in steep-slope vineyards. The project generated 12 indexed publications, WETA and AgRob prototypes at TRL6 and reusable software including VineSLAM, AgRob-PP and AgRob4DEMETER.

My research has also progressively expanded from robot autonomy towards perception and understanding of the biological environment. I have promoted the integration of deep learning, multimodal sensing, spectral technologies, RADAR and edge computing for detecting trunks, fruits, flowers, pruning structures, crop condition and other agronomic features. This has created a second research direction in which robots evolve from autonomous mobility platforms towards machines capable of perceiving plants and supporting selective operations.

VineShield-DT represents a complementary evolution from individual robotic systems towards distributed physical-digital infrastructures. The project integrates a large network of intelligent insect traps with environmental, geospatial and agronomic information to model and predict the risk associated with *Scaphoideus titanus* and Flavescence Dorée. This work extends technologies developed around SmartTRAP towards regional-scale monitoring, predictive models and decision support, illustrating how sensing, AI and IoT can complement robotics in precision agriculture.

Overall, I have used competitive R&D projects as a mechanism for cumulative scientific development rather than isolated demonstrations. More than 70 submitted proposals resulted in around 40 funded projects and approximately €7.3M attracted to support my research team, producing over 20 prototypes above TRL5. The recently approved **ecoBOTs.pt** initiative represents the next step: consolidating modular field-robotics technologies and accelerating their progression from research prototypes towards deployable agricultural and forestry robotic systems.

This trajectory reflects the central idea underlying my research: **field robots should not be isolated prototypes, but reusable, adaptive technological ecosystems in which algorithms, software, sensing, hardware and accumulated field knowledge can progressively be transferred between applications, robots and environments.**

2.b. Contributions to the training and career development of researchers and/or research teams

A contribution of which I am particularly proud is the creation of a sustainable multidisciplinary research team in field robotics. In 2017, I established at INESC TEC the research line that evolved into **TRIBE Lab – Robotics and IoT for Precision Agriculture and Forestry**. The core team grew from 4 researchers in 2017 to 27 in 2025, reaching 33 researchers when supervised MSc students and visiting researchers are included.

I have sought to build more than a group executing projects: my objective has been to create an environment in which young researchers progressively become scientifically and technically independent. By 2025, I had co-supervised **nine completed PhDs and ten ongoing doctoral projects**, alongside MSc students and postdoctoral researchers. Several researchers who joined the team as students or junior researchers subsequently progressed to PhDs, permanent research positions or leadership responsibilities within the laboratory.

I encourage researchers to take ownership of scientific questions, technologies and experimental campaigns and progressively to lead publications, project tasks, proposals and technological developments. Participation in European projects, international collaborations, field trials and interaction with industry are deliberately used as training instruments.

TRIBE is consequently multidisciplinary by design, bringing together robotics, embedded systems, AI, sensing, agronomy and forestry. As coordinator of TEC4AGRO-FOOD, I have extended this approach beyond my laboratory by promoting collaboration between researchers from different INESC TEC centres.

I consider **building people, teams and the conditions for scientific independence** one of the most important and lasting outputs of my research career.

2.c. Contributions to the scientific community

I contribute to the research and innovation community through scientific evaluation, European research agendas, standardisation and open research. I am a founding member of the Portuguese Robotics Society, an IEEE member and contribute to the **Agrifood Topic Group of ADRA – AI, Data and Robotics Association**, helping connect robotics and AI research with European agri-food priorities.

I regularly serve as an independent expert evaluating competitive research and innovation proposals, including European Commission/EIC, ANI and CCDR-N programmes. In 2025 alone, this included six EIC Pathfinder Open proposals, in addition to national R&D evaluations.

I also represent INESC TEC within the Agricultural Industry Electronics Foundation, contributing to discussions on ISOBUS security and related ISO standards. This provides a direct interface between research and the international agricultural machinery ecosystem.

I promote reuse of scientific results through open-source research software. My team has generated around 30 software repositories, with tools including **VineSLAM, AgRob-PP and AgRob4DEMETER** released under open/dual licensing models, allowing academic reuse while preserving routes for commercial exploitation.

Through TRIBE and TEC4AGRO-FOOD, I also promote interdisciplinary research and international collaboration at the intersection of robotics, AI, sensing, agriculture and forestry.

2.d. Contributions to society

My research strategy deliberately seeks to shorten the distance between scientific results and their use in agriculture and forestry. The technologies developed by my team address societal challenges including labour shortages, worker safety, pesticide exposure, resource efficiency and the environmental sustainability of agricultural and forestry operations.

I have pursued this through long-term collaboration with farmers, machinery manufacturers and technology companies, moving research results from laboratory prototypes to field demonstrations and industrial exploitation. Examples include precision spraying with WETA, multi-operation automation with Modular-E, forestry robotics with Modular-X, and large-scale pest monitoring and decision support through VineShield-

DT.

This translation pathway has generated patents, industry-funded R&D, software with dual licensing models and robotic prototypes progressing towards commercial exploitation. In 2026, I co-founded **VIFIELD**, creating a dedicated route for transferring field-robotics technologies developed from this research ecosystem to the market. The approved **ecoBOTs.pt** initiative further strengthens this transition towards deployable robotic solutions for agriculture and forestry.

I also promote direct engagement with users and technology providers through demonstrations, workshops and initiatives such as **Synergy Day**, bringing together researchers, farmers and companies around robotics and digital agriculture.

My objective is that research generates not only publications, but also **people, technologies, companies and solutions that create lasting societal and economic value.**

3. Scientific production and/or selected activities

1. Santos, F.N. et al., "Towards a Reliable Robot for Steep Slope Vineyards Monitoring", Journal of Intelligent & Robotic Systems.

This work established an early foundation of my research on field robotics for challenging vineyards, integrating autonomous navigation and robotic design for steep and irregular terrain. I led the development of the robotic research line that subsequently evolved through several generations of AgRob platforms.

2. Santos, F.N. et al., "Localization and Mapping for Robots in Agriculture and Forestry: A Survey", Robotics.

This work systematised the specific localisation challenges of agricultural and forestry environments and helped frame my subsequent research on GNSS-independent and multi-layer localisation. I led this research direction, which later resulted in VineSLAM and its integration in multiple field robots.

3. VineSLAM – multi-layer localisation and mapping for agricultural environments.

VineSLAM translates this research into reusable open-source robotic software, combining complementary representations for robust localisation in agricultural environments. I led its conception and progressive integration into AgRob, WETA, Modular-E and other robotic platforms.

4. SCORPION / WETA autonomous precision-spraying system.

I conceived the proposal, assembled the consortium and coordinated the €2.5M H2020 Innovation Action. The research integrated localisation, slope-aware planning, autonomous mission execution and precision spraying into robots validated in steep-slope vineyards, generating 12 indexed publications and two TRL6 robotic prototypes.

5. Modular-E / Modular-X field-robotics architecture.

I led the research trajectory towards modular electric robots capable of supporting multiple agricultural and forestry operations. Modular-E reached TRL6 and was awarded second-best robot at FIRA 2024, illustrating the transition of my research from individual algorithms towards reusable autonomous field-robotics platforms.