NAUTEC – Intelligent Automation and Robotics: Research Overview and Collaboration Opportunities

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***Abstract*— An overview of the Intelligent Automation and Robotics Research Group - NAUTEC, affiliated with the Federal University of Rio Grande. The group conducts research and development in Modeling and Control, Graphics Processing, Computer Vision, Robotics and Mechatronics, Embedded and Real-Time Systems, Machine Learning, and Intelligent Systems. This work describes the NAUTEC Group's profile, leadership, members, main research lines, ongoing and completed projects, laboratory infrastructure, and perspectives for collaboration. The group's activities support the development of technology aligned with industry needs through competitively funded research projects and multidisciplinary robotics collaboration.**

I. INTRODUCTION

The NAUTEC, Research Group on Automation and Intelligent Robotics, aims to research and develop new computational techniques and algorithms for the analysis, modeling, and control of sensor and actuator networks, whether these constitute Automation Systems or Robotic Systems*. Since its founding in 2001, the group has been developing research mainly focused on new applications in education; the oil, gas, and energy industry; coastal and oceanic ecosystems; and, more recently, military defense and logistics.

II. NAUTEC'S FEATURES

This section presents the main features of NAUTEC, including its human and physical resources and expertise.

A. NAUTEC's Team

It comprises staff (professors and technicians), researchers (postdoctoral fellows), graduate students (doctoral and master's candidates), and undergraduate students. Professors Paulo Lilles Jorge Drews Junior, and Silvia Silva da Costa Botelho are the group leaders. In addition to the leaders, several professors, researchers, and students are members of the group. To better understand the group, Table I presents the team composition indicators. Note that the sum of members across research lines exceeds the group total, as some members contribute to more than one line. Students are enrolled in undergraduate courses at FURG, including Computer Engineering, Automation Engineering, Mechanical Engineering, and, recently, Robot Engineering. The graduate students are largely from the Master's and Doctorate Program in Computer Engineering (PPGCOMP) and the Master's and Doctorate Program in Computational Modeling (PPGMC). A Specialization in Robotics and Artificial Intelligence (PRIA) is another initiative of the group, together with UTEC-Uruguay and UNRAF-Argentina.

B. NAUTEC's Expertise Fields

The group is ranked in Computer Science rankings such as `https://csrankings.org/` and `https://csindexbr.org/`, being positioned among the Top-3 in Brazil and South America in the robotics area. Considering `https://roboranking.org/`, the group is ranked in the Top 4 in South America. The research of NAUTEC focuses on three areas of application. The first refers to Automation and Intelligent Robotics in Industry, with an emphasis on oil and gas, including the development of autonomous systems, advanced sensing, robotic inspection, unmanned aerial vehicles, and solutions for industrial environments. The second area encompasses Automation and Intelligent Robotics in the Coastal and Oceanic Ecosystem, integrating technologies for environmental monitoring, automated data collection, onboard remote sensing, autonomous surface vehicles, and applications geared towards sustainability and the blue economy. The third is dedicated to Automation and Intelligent Robotics in Education, promoting the training of highly qualified professionals through experimental platforms, technological competitions, scientific initiation projects, and the development of active methodologies based on robotics and intelligent systems. Based on the team composition figures presented in Table I and the areas of expertise, the group is subdivided by research lines, as registered with CNPq.

C. NAUTEC's Infrastructure

The NAUTEC Group has a computational and robotics infrastructure that includes the Intelligent Robotics Automation Laboratory, responsible for developing autonomous systems such as ROVs and UAVs for inspection and monitoring; the FBot Laboratory, which works with competition robotics; and the Digital Image Processing Laboratory. The NAUTEC provides infrastructure (Table II) and environments for research, development, and innovation in robotics, automation, and artificial intelligence, enabling researchers and engineers to tackle technological challenges.

D. NAUTEC's Partnerships

The NAUTEC research group consolidates its activities through a network of collaborations that integrate academic

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*Available in: `https://nautec.furg.br/`

TABLE I
TEAM COMPOSITION BY ACADEMIC LEVEL AND RESEARCH LINES

Academic Level	Researchers	Student	Technicians	Research Lines	Student	Researchers
PhD (Doctorate)	31	14	0	Modeling and Control	11	11
Master's	2	15	1	Graphics Processing	23	15
Specialization	-	0	1	Robotics and Mechatronics	39	18
Undergraduate	-	28	1	Embedded and Real-Time Systems	9	7
				Intelligent Systems and Machine Learning	29	17

TABLE II
NAUTEC'S EQUIPMENT BY CATEGORIES

Categories	Physical Equipments
Underwater and Marine Robotics	ROV, BlueROV2, BlueBoat USV, Sonar System
Aerial Robotics and Sensors	UAV Drones, Drone Camera, Drone Spotlight, Cable Power Supply, High-Speed Camera, Laser Lighting
Robotics Platforms	Mobile Robotic System, Mini Robots, PatrolBot, Robotic Manipulator, Autonomous Robot Platform
Manufacturing and Instrumentation	3D Printers, Linear Welding System, Laser Equipment, Micrometer, AHRS (MTi-G)
Measurement and Perception Systems	Motion Tracking Station, Motion Capture Camera, 3D Laser Sensor, Indoor GPS, Thickness Sensor, Digital Thickness Meter

institutions, funding agencies, and the industrial sector. In the academic and technological sphere, the group maintains partnerships with the Department of Electronic Engineering and Computer Science (UFMG-MG), the Department of Informatics and Statistics (UFSC-SC), the Institute of Exact Sciences and Technology (UFAM-AM), the Engineering Center (UFPel-RS), and the Federal Institute Sul-Rio-Grandense (IFSul-RS) and Rio-Grandense (IFRS), among other groups. Internationally, NAUTEC collaborates with the University of Freiburg (Germany) through the Alexander von Humboldt Foundation, CSIRO (Australia) for environmental monitoring research, ITA (Brazil) for inspections based on unmanned aerial vehicles, and UTEC (Uruguay) and UNRAF (Argentina) through the joint PRIA specialization program. These researches are strengthened by the technical and financial support of the following main national agencies: the Brazilian FINEP (RJ), the Brazilian Industrial Research and Innovation Association (EMBRAPII-DF), the Rio Grande do Sul State Research Support Foundation (FAPERGS), the National Council for Scientific and Technological Development (CNPq), and PETROBRAS (RJ). Furthermore, cooperation with the private sector, exemplified by partnerships with Automni Robotized Logistics (SP), AEL Systems (RS), and Freedom Electric Vehicles (RS), demonstrates NAUTEC's commitment to technology transfer and the development of innovation applied to industry and society. The group also created the ITEC/FURG EMBRAPII Unit, an innovation center that is linked to the Oceantec Science and Technology Park of the Federal University of Rio Grande. EMBRAPII has been accredited since 2020, accelerating technological development in the productive sector through innovation projects focused on robotic systems and automation, leveraging computer vision and data science tools. This EMBRAPII Unit raised more than 50 million real in robotics systems and automation projects.

III. NAUTEC'S PROJECTS

Recent projects of the NAUTEC Group will be presented, including those in progress or completed.

A. Information-Hungry framework for Robotic Iterative Search - IHRIS

The project is funded by the Humboldt Foundation in collaboration with the University of Freiburg. The Information-Hungry Framework for Robotic Iterative Search (IHRIS) project aims to fill this gap by integrating an iterative cycle of perception and action (Fig. 1). In each iteration, the system interprets the scenario, estimates uncertainties, and defines actions to acquire relevant information, thereby promoting a continuous process of decision refinement. The goal is to enable independent general-purpose behavior capable of operating in complex, unstructured environments, thereby reducing dependence on manually labeled databases.

B. Intelligent Robotics for Autonomous Tasks in Industrial Environments - RITA

The project is funded by CNPq and aims to develop intelligent robotic agents for planning and executing tasks in industrial environments, using advanced service robotics and AI technologies. The proposal includes the design of autonomous systems with perception, decision-making, and multi-agent cooperation capabilities, favoring more flexible, adaptive, and scalable automation models. The central challenge lies in optimizing and automating industrial processes in dynamic, unstructured environments, where traditional approaches impose operational constraints and offer limited adaptability. The constant search for robust solutions to autonomous navigation and collaborative coordination among multiple robots underscores the need for scientific advances in this domain. The hypothesis is that integrating service robotics, machine learning, and sensor fusion for complex industrial applications. Although recent literature reports significant progress in navigation and multi-agent

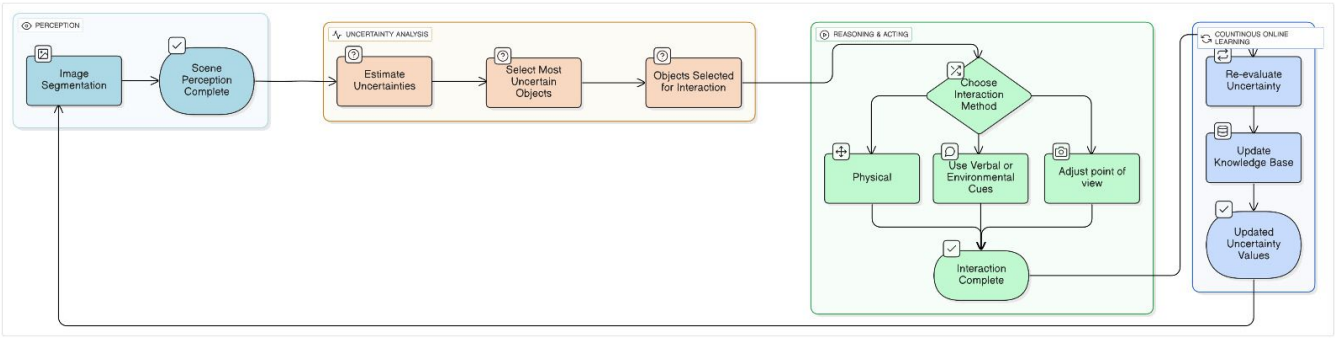


Fig. 1. Methodology of the IHRIS project focused on robot learning.

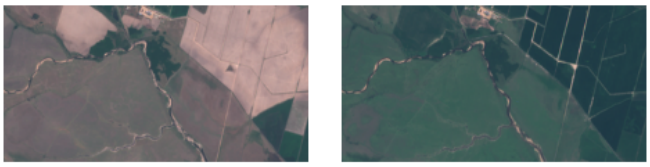
cooperation, gaps remain in transferring these technologies to real industrial environments. Methodologically, the project involves prospecting for and evaluating emerging technologies, developing perception and planning algorithms, conducting computational simulations, and conducting field experimental validation. The collaboration between teams from Brazil, Spain, and Germany strengthens technical feasibility and expands the potential for scientific impact and industrial innovation.

C. Autonomous Robotic Systems Applied to Logistics - SARAL

The SARAL project, funded by CNPq in collaboration with Automni Robotized Logistics, aimed to develop and integrate technologies to meet the modern industry's demand for intelligent, independent systems. The work focused on integrating robotics and artificial intelligence to create systems that understand the environment, make decisions, and adapt to different operating conditions. The project developed algorithms and methods that increase the autonomy of automated pallets, enabling them to transition from executing pre-programmed commands to agents capable of interpreting the environment, planning dynamic routes, and operating efficiently in real time. To achieve this, machine learning techniques for visual and sensory perception, optimization-based motion planning, real-time adaptive control, and hybrid computational architectures are explored.

D. Multi-sensor Navigation in the Context of GNSS Degradation

The project is developed in partnership with AEL Systems. The project aims to investigate and propose solutions to airworthiness challenges in environments with GNSS signal restrictions or degradation, with an emphasis on unmanned aerial platforms (Fig. 2). The increasing incidence of interference, intentional jamming, urban masking, and confined environments poses significant challenges to navigation based exclusively on global positioning systems. In this context, the proposal seeks to develop alternative and complementary methods for geographic position estimation, ensuring adequate levels of safety, reliability, and operational continuity in civil and military applications. To achieve this objective, the project foresees integrating multiple technologies, combining



(a) Image from January 2022. (b) Image from January 2023.

Fig. 2. GNSS Project and its challenge associated with the identification of places in aerial images that suffer season changes.

Artificial Intelligence and Computer Vision with the fusion of heterogeneous sensors, including inertial measurement units (IMUs), cameras, LiDAR, and barometers. Visual odometry techniques, SLAM (Simultaneous Localization and Mapping), deep learning for geographic pattern recognition, and advanced filtering and state estimation algorithms will be investigated. The multimodal approach will enhance resilience to GNSS failures and interference, enabling safer, more adaptable autonomous navigation in dynamic scenarios.

E. Bird's Eye View Robotics for Logistics Environments - BEVLOG

BEVLOG is developed in collaboration with Automni Robotized Logistics and aims to build a perception system with a Bird's-Eye View (BEV) representation for logistics robotics. This system can build and maintain semantic and geometric representations using deep learning (Fig. 3).

F. Navigation of Electric Logistics Vehicles - LOGNAV 4.0

The LOGNAV project is linked to an initiative funded by the Freedom Electric Vehicles Company, which aims to develop an advanced navigation and perception system to automate internal cargo transport in industrial environments, such as factories, production plants, and logistics warehouses. The proposal is based on the operation of intelligent convoys to increase logistic efficiency, reduce operational costs, and enhance safety and traceability within internal material flow. The convoys consist of an autonomous electric tug integrated with intelligent trailers, cameras, and distance sensors, allowing autonomous and cooperative navigation in the industrial environment. The system incorporates environmental perception algorithms, route planning, and

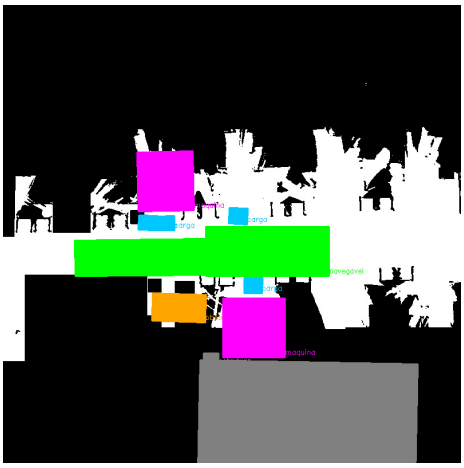


Fig. 3. BEV representation by the BEVLOG Project for a logistic scenario.

coordinated control, enabling users to program routes and configure loading and unloading points at stations or production cells. These points are identified by strategically placed visual landmarks, automatically recognized by the embedded systems of the trailers and the tugboat, ensuring precision in coupling, stopping, and executing logistical operations. The proposed system combines computer vision, sensor fusion, and embedded intelligence to enable flexible and scalable internal transport aligned with Industry 4.0.

G. Autonomous Robotics for Environmental Monitoring between FURG, UFAM, and CSIRO - RAMA

This project is funded by CNPQ and developed in collaboration with CSIRO and UFAM. Also, it establishes a strategic collaboration between Brazil and Australia, bringing together leading researchers to develop advanced autonomous robotics for monitoring diverse ecosystems, including Amazonian, Gaucho, and Australian biomes. The cooperation aims to develop algorithms for perception, navigation, mapping, and coordination among unmanned ground, aerial, and aquatic vehicles, leveraging AI to enhance environmental monitoring across diverse contexts. The primary challenge addressed is the current limitation in the monitoring capacity in remote areas, which hinders the rapid identification of critical environmental changes. This international partnership serves as a solution to promote more efficient, comprehensive, and adaptable monitoring. The central research question explores how the Brazil-Australia partnership can optimize the development of autonomous systems to improve unmanned vehicle navigation for environmental data collection and analysis. The project strategy involves the collaborative development of algorithms, pre-validation simulations, and validation in real-world environments, combining the expertise and resources of both nations to create integrated, efficient environmental monitoring technologies.

H. Active Perception to Account for Uncertainty in Deep Learning Applied to Robotics

The project is funded by the Humboldt Foundation in collaboration with the University of Freiburg. Active perception is a relevant field in computer vision, but it is used mainly in robotics. An active perceptual system actively seeks information and does not passively rely on information that falls onto the image sensor. Recent developments in computer vision were boosted by competitions with both academia and industry and by the availability of high-quality labeled data. Both enable the advancement of learning-based methods using deep learning, achieving state-of-the-art performance. Despite these advances, the application of deep learning in robotics raises very specific problems and research questions that remain open. Given these challenges, this project seeks to answer the question: Is it possible to properly estimate calibrated uncertainty in detection and recognition tasks using deep learning in robotics? How can we actively perceive the detection/recognition target to reduce task uncertainty?

I. 3D Laser Scanning Data Processing Embedded in UAVs - AEROSCAN

This project is developed in collaboration with ITA-Brazil and funded by the Brazilian Oil company - PETROBRAS. The oil and gas sector requires dimensional inspection of structural elements, both during construction and in the final inspection, the latter being necessary for the creation of a final work document known as the As-Built. This dimensional inspection uses manual measuring instruments, such as tape measures, bubble levels, and graduated scales, as well as metrological measuring equipment, such as total stations, optical levels, and protection meters. Due to the considerable scale of projects, whether refineries or platforms, the time required to measure structures and other construction becomes a crucial factor in finalizing documentation. Therefore, this research project aims to develop data processing techniques for data obtained from 3D laser scanning mounted on UAVs or Remotely Piloted Aircraft (RPAs).

J. Pipeline Cleaning Robot - CleanBot

The project was developed in partnership with the Yara Brazil Company. It proposes developing a robotic system, Cleanbot, as a functional prototype for automated cleaning of suction pipes in industrial fertilizer plants. These environments feature high particle concentrations, chemical incrustations, and adverse operating conditions, making conventional maintenance procedures complex, costly, and often unsafe for human operators. In this context, Cleanbot emerges as a technological solution that automates internal inspection and cleaning processes, thereby improving operational efficiency, reducing unscheduled downtime, and enhancing industrial safety. The system will be structured into three main integrated modules. The first module corresponds to the locomotion mechanism responsible for controlled movement within the pipes and should include solutions for traction, stability, and adaptation to varying diameters and geometries. The second module is the perception system, composed of sensors dedicated to mapping the internal environment, detecting obstructions, evaluating incrustations, and monitoring

operating conditions, enabling assisted or autonomous navigation. Finally, the actuation system will be responsible for the actual cleaning process, and may incorporate mechanical devices, pressurized jets, or other specific mechanisms for residue removal. The integration of these three modules will allow the validation of a robust prototype, capable of operating in harsh industrial environments and serving as a basis for future applications in robotic maintenance.

K. Hybrid Underwater Aerial Vehicle - HYDRONE

The Hydrone project (Fig. 4) establishes the conceptual and technological foundation for this trajectory. Its primary objective is to develop an unmanned hybrid vehicle capable of transitioning between air and water, integrating control and automation systems that ensure stability, performance, and reliability in both domains. The proposal is grounded in recent advances in micro-controllers, embedded systems, and navigation technologies, which have enabled the emergence of air–water hybrid vehicles capable of executing missions in mixed environments [1]. The project focuses on dynamic modeling, control strategy development, and system validation through computational simulations, prototyping, and real-world experiments, thus establishing the technical groundwork for future applications in coastal and maritime regions. The project is developed in partnership with UFMG, UFSC, IFSUL, UFPEL, and IFRS, among others, in Brazil.

Building on this foundation, HydroneLE, funded by CNPq expands the initial scope by addressing one of the main limitations of hybrid vehicles: restricted energy autonomy [2]. Although Hydrone represents a significant breakthrough in integrating aerial and aquatic navigation, operational time remains limited by onboard battery capacity. HydroneLE therefore proposes an integrated system composed of an aerial–aquatic mobile robot associated with a surface mobile base equipped with recharging capabilities. This base functions as an energy and logistic support station, enabling extended-duration offshore operations. In doing so, the project introduces the concept of a cooperative system in which the vehicle and the support base operate in an integrated manner to extend mission time and enable more complex applications in maritime environments. HydroneLE 2.0 continues this development, funded by CNPq. The SubHydrone project consolidates and industrializes this research line, with a focus on offshore and subsea operations, particularly in the oil and gas sector. Approved in a public call from Brazil's Ministry of Science, Technology and Innovation (MCTI), FINEP (Funding Authority for Studies and Projects), and the National Fund for Scientific and Technological Development (FNDCT). The project proposes an integrated robotic system composed of an aerial–underwater vehicle and a mobile surface base with recharging and autonomous displacement capabilities. Its distinguishing feature is the expansion of the concept to include missions with aerial phases, surface navigation, and submerged operations, thus reducing dependence on support vessels and multiple specialized systems. Validation is carried out through simulations, prototyping, and experimental testing, ensuring technical robustness and applicability in industrial environments. Complementing this technological evolution, HydroneAuto, funded by FAPERGS, introduces an advanced layer of intelligence and decision-making autonomy to the hybrid systems under development. Its central objective is to advance a robotic architecture capable of intelligent autonomous navigation in multi-modal environments, addressing challenges such as stability under distinct physical dynamics, hydrodynamic and aerodynamic efficiency, energy limitations, and adaptive control. The project proposes incorporating intelligent planning algorithms, sensor fusion techniques, and adaptive control strategies to enhance real-time decision-making capabilities. Additionally, it foresees integration with a mobile surface base responsible for logistic support, energy recharging, and navigation assistance, reinforcing the collaborative system concept developed in earlier initiatives. The system's dynamic behavior is analyzed through computational simulations in both aerial and underwater environments, complemented by experimental validation using real prototypes to ensure technical robustness and operational reliability.

The interconnection between the four projects reveals a structured technological progression. Hydrone establishes the foundation for the air–water hybrid vehicle and its control systems; HydroneLE extends operational autonomy through integration with a mobile recharging base; SubHydrone consolidates the system for complex industrial offshore and subsea applications; and HydroneAuto adds an advanced intelligence layer, elevating autonomy, adaptability, and efficiency. Together, these initiatives form a comprehensive technological ecosystem aimed at developing autonomous hybrid robotic solutions capable of operating more safely, efficiently, and independently in strategic maritime environments, thus advancing scientific research, driving industrial innovation, and strengthening national technological sovereignty. The Hydrone, HydroneLE, HydroneLE2.0, SubHydrone, and HydroneAuto projects form an integrated, progressive scientific and technological development pathway focused on creating hybrid mobile robotic systems capable of coordinated operation in aerial, surface, and underwater environments [3]. This research line addresses the growing demand for technologically applicable solutions to coastal and offshore environments, particularly in the Brazilian context, which includes approximately 8,500 kilometers of coastline and intense economic activity in the maritime, port, and energy sectors. These environments, often hostile to human presence, require autonomous systems capable of performing inspection, monitoring, mapping, and data collection tasks safely, efficiently, and with extended operational endurance.

IV. Opportunities for collaboration

The NAUTEC group aims to expand its scientific and technological contributions to intelligent automation and robotics through national and international collaborations. Future research includes improving autonomous robotic systems to operate in multimodal environments by integrating aerial, terrestrial, surface, and underwater robots. Special

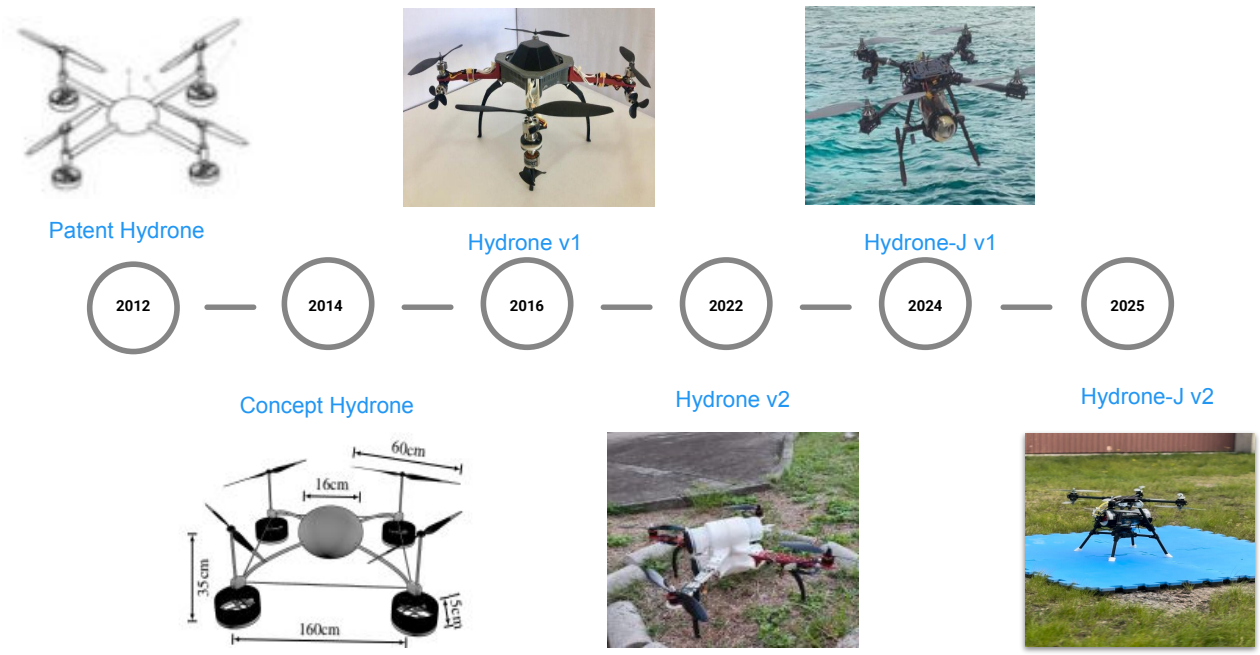


Fig. 4. Timeline of Hydrone's Project: concepts and prototypes developed in the past ten years.

attention will be paid to robust, intelligent development of perception systems, sensor fusion strategies, resilient navigation in non-GNSS environments, intelligent decision-making, and control architectures based on machine learning and artificial intelligence. Another perspective lies in integrating robotics with environmental monitoring and sustainability. Projects related to aquatic ecosystem monitoring, such as the partnership with SiMCosta, coastal observation, and biodiversity preservation, highlight the potential of autonomous systems to support the acquisition of large-scale environmental data. These initiatives align with global challenges in climate change, resource management, and the development of the blue economy, positioning NAUTEC as a contributor to sustainable technology. NAUTEC actively seeks partnerships with universities and research centers for joint research projects, exchange programs, and collaborative student supervision. The group is also interested in strengthening cooperation with industry through applied research, technology transfer, and innovation programs. Partnerships with companies and public bodies enable the development of solutions geared towards Industry 4.0, intelligent logistics, autonomous inspection, and industrial robotics for hazardous environments. Collaborative initiatives with sectors such as oil and gas, energy, logistics, and advanced manufacturing offer opportunities to jointly develop prototypes, pilot projects, and validate robotic technologies.

V. CONCLUSIONS

An overview of the NAUTEC group was presented, highlighting its research lines, infrastructure, partnerships, and projects in intelligent automation and robotics. Over the past 25 years, the group has trained hundreds of students who work in robotics companies in Brazil and around the world, and has contributed to the creation of successful technology startups. Looking forward, NAUTEC seeks to expand its network of collaborators and strengthen international cooperation. The group welcomes partnerships with universities, research centers, and industry partners interested in joint research projects, researcher exchange programs, collaborative supervision of students at all levels, and shared use of laboratory infrastructure. Scholarships are available for visiting students and researchers. Interested parties are invited to visit the link `https://nautec.furg.br/` or contact the authors to explore collaboration opportunities.

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