PhD scholarships tied to subject-related scholarship and financed by external Institutions/Organizations:

1. "Context-Aware Augmented Reality Systems for Human-Centered Guidance in Complex Environments" (50% financed by COVISION LAB SCARL/KgmbH, supervisor Prof. Patrick Dallasega, dr. Marco Boschetti)

Augmented Reality (AR) has emerged as a powerful technology for delivering situated, real-time information directly within a user's field of view. When combined with Computer Vision and Deep Learning, AR systems can adapt content dynamically based on environmental context, user behavior, and system state. This capability is particularly valuable in complex, safety-critical, or knowledge-intensive environments such as industrial maintenance, training scenarios, laboratories, and cultural heritage spaces. Despite significant progress, current AR systems often rely on static instructions, manual triggering of content, or controlled environmental conditions. They frequently struggle with robustness under dynamic head movement, variable lighting, and real-world occlusions, while also imposing high cognitive load on users. Moreover, accessibility and inclusion remain underexplored, limiting the adoption of AR systems by seniors, people with disabilities, and non-native speakers. This research is motivated by the need for context-aware, robust, and inclusive AR systems that combine Computer Vision, bio-signal interpretation, machine data, and virtual assistants to deliver adaptive, explainable, and low-cognitive-load guidance across diverse application domains. The primary objective of this PhD is to design, implement, and evaluate a context-aware AR system that adapts instructions and explanations in real time using multimodal context sensing and intelligent virtual assistance.

The proposed research focuses on the development of a context-aware AR system that dynamically adapts its behavior and content to the user, the environment, and the operational situation. Context awareness is achieved by integrating multiple information sources, including operator bio-signals such as stress levels and cognitive workload indicators, spatial context information such as location, orientation, and proximity to relevant objects, as well as machine and system data including operational status, error states, and active modes. By fusing these data streams, the system is able to tailor AR instructions in real time, ensuring that guidance is relevant, timely, and aligned with the user's current context. A central technical challenge addressed in this work is robust AR interaction in real-world conditions. The system aims to achieve reliable spatial registration even under dynamic head movement, variable lighting, and in uncontrolled industrial or public environments. At the same time, particular emphasis is placed on minimizing cognitive load through carefully designed visualizations and interaction strategies, while maintaining high task accuracy, especially in complex or safety-critical scenarios. To enhance usability and understanding, the system integrates a multimodal virtual assistant that acts as an intelligent guide. This assistant is capable of explaining the context and rationale behind tasks, providing step-by-step instructions, and answering user questions using natural language interaction.

Explanations are adapted to the user's level of expertise and the specific application domain, allowing the same system to support for example expert technicians as well as trainees. The effectiveness and versatility of the proposed approach will be validated through multiple application scenarios, including industrial maintenance and diagnostics, industrial training, guided laboratory visits, and museum or cultural heritage experiences. These use cases enable a comprehensive evaluation of the system's technical robustness, usability, and impact on efficiency and learning outcomes. Finally, accessibility and inclusion are treated as core design principles rather than add-on features. The system incorporates inclusive interaction mechanisms such as real-time captions, audio descriptions, adaptive text size and contrast, and multilingual support. Personalization features are developed to accommodate diverse user groups, including seniors, people with disabilities, and non-native speakers, ensuring that the AR system can be effectively and comfortably used by a broad and diverse audience. The expected contributions of this PhD are the following. i) A novel context-aware AR framework integrating bio-signals, spatial context, and machine data. ii) Robust computer vision and deep learning methods for real-world AR deployment. iii) A domain-adaptive virtual assistant for explanation-driven AR guidance. iv) Design guidelines for low-cognitive-load AR interfaces in safety-critical environments. v) A comprehensive approach to accessibility and inclusion in AR systems. vi) Empirical evidence of AR's impact on efficiency, accuracy, and user experience across multiple domains.

The system will be implemented and evaluated in several representative scenarios:

- Maintenance & Diagnostics
  - Context-aware inspection guidance
  - Explanation of faults and corrective actions
  - Goal: reduce downtime
- Industrial Training
  - Adaptive training sequences
  - Explanation of task rationale ("why this step is important")
  - Performance and learning outcome assessment
- Laboratory Visits
  - Explanation of demonstrators and experiments
  - Interactive exploration guided by the virtual assistant
- Museum Visits
  - Contextual storytelling for art artifacts
  - Personalized explanations based on visitor profile and interests

2. "Design and development of innovative sustainable, biodegradable membranes for flexible electronics and environmental sensing applications" (50% financed by FONDAZIONE BRUNO KESSLER, supervisor Prof. Luisa Petti, dr. Andrea Gaiardo)

The rapid expansion of flexible electronics and distributed environmental sensing systems demands materials that combine high performance with minimal environmental impact. This PhD project aims to design and develop innovative sustainable, biodegradable membranes tailored for next-generation flexible electronic and sensing applications. The research will focus on bio-based polymers and naturally derived nanomaterials to engineer membranes with tunable mechanical flexibility, controlled porosity, and functional surface properties. Advanced fabrication techniques, including solution casting, electrospinning, and green solvent processing, will be explored to create thin, robust, and conformable membranes compatible with low-temperature device integration. The project will investigate strategies to enhance electrical functionality through the incorporation of conductive biocompatible fillers while preserving biodegradability and environmental safety. Comprehensive characterization will evaluate mechanical strength, thermal stability, permeability, electrical performance, and degradation behavior under realistic environmental conditions. By integrating materials science, sustainable chemistry, and device engineering, this research seeks to bridge the gap between eco-friendly materials and high-performance flexible systems. The expected outcomes include scalable membrane fabrication routes, improved lifecycle sustainability, and demonstrator prototypes for environmental monitoring. Ultimately, the project aims to contribute to circular electronics and reduce the ecological footprint of emerging sensing technologies.