PhD scholarships bound to specific research topics/areas and financed by external organizations

Project 1: Machine Learning and Artificial Intelligence methods applied to robotics for key alpine applications
Financed by: Eurac Research
Supervisor: Prof. Karl Dietrich von Ellenrieder, Dr. Abraham Mejia

Project Description: The idea is to implement intelligence in robotic platforms using sensor data approaches to solve two key alpine applications: Diseases in Mountain agriculture and Search and Rescue operations in avalanches. The robots will automatically perform tasks in complex situations that, until today, have required humans for identifying and monitoring crop conditions in agricultural applications, or victims in search and rescue applications. The methodology consists of using a pre-defined area within which the robots, both aerial and terrestrial, will identify a specific pattern (machine learning approach based on real data), which we will call the subject. The robots will navigate to the subject, avoiding obstacles in the area (eg. collisions with trees, or changes in terrain due to the avalanche) by making effective decisions. The integration of sensor-based data is crucial for making decisions about the identification of the subject, how to approach the subject, and which tasks the robot should perform during the mission. A collaborative swarm strategy, using aerial and terrestrial robots will be explored to overcome the limitations of time, space, and sensing data.

Project 2: Improving High-Speed Data Transfer with Ultra-Thin PCBs
Financed by: Fondazione Bruno Kessler
Supervisor: Prof. Luisa Petti**,** dr. David Novel, Prof. Philippe Velha

Project Description: The proposed topic of the thesis is related to ultra-thin PCBs, tailored for applications where intricate designs demand cutting-edge space optimization, such as in satellite payloads or large-scale scientific experiments. In detector systems, minimizing PCB thickness is often necessary to reduce dead material in the active region, where the sensor is highly sensitive to any perturbations. This is crucial for both space-based and ground-based scientific experiments. The PhD candidate will undertake a comprehensive study encompassing (i) design and simulation, (ii) manufacturing and (iii) experimental campaigns for the high-frequency characterization (up to 30 GHz) of custom Printed Circuit Boards (PCBs) and various bonding schemes to chip-to-flex interconnections. Ultra-thin PCBs will either be manufactured in FBK via custom patent-pending techniques or by commercial standards to be used as a benchmark. The candidate will design and simulate the PCB stack, including differential pairs and controlled impedance routing. Full process control during manufacturing will enhance the model development, allowing for the identification of specific contributions from the macroscopic geometric features (such as the shape of the metal leads) to microscopic elements like lead roughness, grain size (see Mayadas-Shatzkes model) and bonding types. The study will explore various bonding techniques, including wire-bonding, TAB bonding and bump bonding for 3D integration. These techniques differ in materials and bonding geometries, affecting impedance and signal insertion loss. Thus, developing a computational model (e.g. using Comsol) and validating it with experimental measurements is critical for selecting the appropriate electronics design. By validating the simulated data with VNA measurements, the investigation aims to deepen the understanding on how each factor included in the model influences the signal integrity of PCBs in high-

frequency applications. Those insights will inform the design of advanced assemblies for scientific detectors in future experiments at CERN or in space missions conducted by ASI, ESA and NASA.

Project 3: From Prototypes to production: Leveraging Digital Twins for Improved Flexibility and Computer Vision in Packaging of Food Manufacturing
Financed by: Loacker Spa
Supervisor: Prof. Oswald Lanz

Project Description: The company has initiated an ambitious research and technological innovation project, focusing on research and development of prototypes for flexible printing to be integrated directly into production lines. In this context, the potential of a digital twin or shadow to simulate a highly complex production process is investigated. The research of this PhD project will play a crucial role in realizing this vision by investigating the capabilities of advanced computer vision algorithms and systems to enhance the fidelity and functionality of the digital twin and the accuracy and efficiency of enabled simulations, ultimately driving innovation in production technology.