TITLE AND ABSTRACT OF THE RESEARCH TOPIC OF PHD STUDENTS IN THE PHD PROGRAM ELECTRONIC AND COMPUTER ENGINEERING (DRIEI)

XL CYCLE

Simone Carta

Tema di ricerca:

Detection and avoidance of counterfeit electronics.

Abstract:

The issue of counterfeiting in electronics is not new, yet it remains a significant concern today. Counterfeit components can compromise the reliability of the systems they are integrated into and, in more severe cases, endanger the safety of individuals and infrastructures. Market dynamics - such as component shortages and obsolescence – often force customers to rely on unofficial sources, referred to as the grey market, creating favourable conditions for counterfeiters to enter the supply chain. To mitigate the risk of counterfeit electronics reaching final products, both detection and avoidance strategies are essential. In particular, non-destructive techniques that can be integrated into large-scale production processes are essential when sourcing from the grey market, especially given the continuous evolution of counterfeiting methods. This research addresses both non-destructive detection and avoidance techniques, with a focus on low-cost, fast solutions, suitable for application to large volumes of devices. In terms of detection, the research investigates non-destructive methods for identifying devices of varying technologies and complexity - from simple analog and digital components to complex systems like printed circuit boards. For simpler devices, electrical characterization is prioritized, while for more complex systems, a combination of features - such as thermal imaging and electromagnetic

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emissions - will be employed, as basic electrical testing may no longer be convenient. Regarding avoidance, the study explores a package-level approach for developing an innovative anti-counterfeiting marking system based on biomolecular assays. This strategy is particularly advantageous for products already on the market, as it does not require modifications at the layout level.

Luigi di Michele

Tema di ricerca:

IoT and Industry 4.0 Technologies for the Analysis and Engineering of Complex Food Systems for the Production of High Value-Added Bakery Supply Chain Products.

Abstract

The research activity is structured around two main areas. The first focuses on the development of models and methodologies for the dielectric characterization of agri-food matrices using microwave sensors and spectroscopic techniques. The goal is to extract the complex permittivity ($\varepsilon^* = \varepsilon' - j\varepsilon''$) and correlate the parameters ε' and ε'' with the intrinsic properties of the products, in order to monitor quality during the key stages of the production process. The second area concerns microwave remote sensing applied to precision agriculture, through the use of radar data for the quantitative estimation of critical variables such as soil moisture and crop health status.

Davide Ghiani

Tema di ricerca:

Anti-Counterfeiting Methods Based on Data Hiding Using Deep Neural Networks.

Abstract:

The capabilities of image processing, watermarking, and biometrics have significantly advanced—alongside the risks of spoofing—due to recent progress in artificial intelligence. Facial recognition has become a key component in identity verification systems, prompting ICAO to establish a standard for the acquisition and formatting of facial images, now integrated into Machine Readable Travel Documents (MRTDs) and Digital Travel Credentials

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(DTCs). However, these images are potentially vulnerable to malicious manipulation, formatting alterations, and quality degradation, especially when subjected to printing processes. While spoofing attacks are typically monitored during acquisition through Presentation Attack Detection (PAD) systems, the need for protection remains when the image is extracted, stored, or redistributed. The aim of this research is to develop a method for authenticating and verifying the integrity of facial images through the application of deep learning-based watermarking techniques.

Marco Ledda

Tema di ricerca:

Learning and Adversarial Learning in Control Systems Design and Modeling.

Abstract

In the field of systems and control, the integration of Machine Learning techniques has opened new avenues for improving system robustness and performances. The complex nature of modern control environments often involves nonlinear dynamics for which it is difficult to have an accurate model on which we can rely. Machine learning, particularly in the form of Deep Learning, has demonstrated significant potential in system identification problems where abundant input/output data is available, thus enable advanced optimization and control strategies. However, the fundamental issue is the development of formal guarantees on reliability and robustness of these methods. This research proposal aims to explore the synergy between control systems and machine learning to develop robust techniques for system identification and control and test the robustness of these systems focusing also on the design of defence strategies against adversarial learning attacks. The motive to integrate machine learning and control systems is driven by the need to address the limitations of traditional control methods when we deal with complex and nonlinear dynamical systems. Traditional control strategies are nowadays considered more robust since they have formal guarantee in terms of stability. However, when accurate formal models are missing, machine learning can contribute to improve control design. Furthermore, the scientific community is currently carrying out numerous studies to provide

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formal guarantees to control methods based on machine learning techniques in terms of stability and robustness. The general objective of the research is to develop an integrated framework that utilizes ML and Control System Design and exploits Adversarial Learning techniques to identify failures modes and vulnerabilities to cyber-physical attacks.

Federico Manca

Tema di ricerca:

Mixed-level approximate computing methodologies in reconfigurable hardware coprocessors.

Abstract

The research focuses on the application of approximate computing methodologies on reconfigurable hardware coprocessors, more specifically on neural networks accelerators on FPGA. The goal is to develop efficient solutions for the implementation of complex, deep learning models on edge devices, which are often subject to strict constraints on resources utilization and energy consumption, area used and latency. Through techniques such as quantization, architecture optimization and mixed-level precision, this work aims at the reduction of computational cost while keeping acceptable performance, easing the integration of AI on embedded scenarios.

Emmanuele Massida

Tema di ricerca:

Vulnerability Detection and Mitigation Techniques: Advancing Privacy-Aware Solutions in Emerging Technologies.

Abstract:

The goal of this research project is to investigate and advance vulnerability detection and mitigation techniques, particularly emphasizing privacy-aware approaches suitable for emerging technologies such as WebAssembly. The project addresses the increasing cybersecurity challenges associated with adopting new digital technologies, specifically the vulnerabilities arising from compiling traditional programming languages into WebAssembly,

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and the privacy intrusions inherent in contemporary security tools. The research aims to comprehensively analyze vulnerabilities introduced by emerging technologies, develop and refine non-invasive, privacy-focused security solutions, and enhance existing reverse-engineering and malware detection tools. Methodologies involve a combination of static and dynamic analysis, machine learning, deep learning, and the use of large language models to explore novel cybersecurity threats and mitigation strategies. Expected outcomes include a thorough vulnerability assessment demonstrated through Proofs of Concept, innovative reverse-engineering tools tailored to enhance security, privacy-aware anti-malware techniques and demonstrators, and adaptable security solutions effective across various environments including desktop, mobile, and cloud platforms. Ultimately, the project seeks to significantly expand the current cybersecurity state-of-the-art, promoting heightened awareness and improved security and privacy practices within the digital ecosystem.

Luca Minnei

Tema di ricerca:

Android Malware Operation.

Abstract:

The research focuses on addressing the significant threat posed by Android malware, which is challenging due to the rapid emergence of new variants. Current static classifiers often become outdated, leaving many devices vulnerable, as there is no existing solution that automatically updates detection models to keep pace with evolving threats. To tackle this issue, this PhD will focus on the creation of a novel self-updating pipeline that ensures Android malware detectors maintain their effectiveness over time. This system is designed to gather new applications and threat intelligence from reputable sources, such as AndroZoo and VirusTotal, every three months. The collected data will be added to a wide dataset for analysis. By utilizing continual learning techniques, the pipeline will retrain a pool of static detectors, allowing them to incorporate new malware without losing knowledge of previous variants. Additionally, I will implement active learning strategies to prioritize human labelling for the most informative samples. Once the models are updated, they will be saved along

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with performance reports, making them readily available for immediate deployment. By automating the processes of data collection, retraining, and model release, this framework aims to provide consistently updated defences against malware with minimal manual intervention.

Marco Murgia

Tema di ricerca:

Advanced Propagation Modeling in Complex Urban Environments for 5G Cellular Networks and the Application of Non-Destructive Radio Frequency Technologies.

Abstract

The research activity is structured around two main directions. The first focuses on improving empirical radio propagation models, such as COST 231 Walfisch–Ikegami and ITU-R P.1411, with the aim of refining 5G coverage prediction in complex urban environments. The study includes comparisons between different models (deterministic, empirical, and machine learning-based), integrated with simulations and experimental measurements, in order to develop a more accurate predictive model to support 5G network design. The second line of research is dedicated to the use of microwave spectroscopy for the rapid and non-invasive detection of adulteration.

Jefferson David Rodriguez Chivata

Tema di ricerca:

Steganography and watermarking methods for proactive DeepFake detection in facial images.

Abstract

In recent years, DeepFake technology has grown quickly, making it possible to create very realistic fake images and videos, especially of faces. This raises serious concerns about privacy, trust, and the spread of false information. Traditional methods to detect DeepFakes often react after the fake content is already created, and they may not work well against new and more advanced DeepFake techniques. This research project focuses on using steganography and watermarking as proactive tools to help stop DeepFakes before they

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spread. These techniques work by hiding invisible information inside facial images before being incorporated in the web or in specific applications. Later, if someone changes or manipulates the image using DeepFake tools, the hidden information can help detect the changes and prove whether the image is real or fake. The goal is to design smart ways to add this hidden information so it stays strong even after the image is edited or shared online. At the same time, it should not affect how the image looks. By doing this, we aim to improve DeepFake detection, protect people's identities, and make digital content more trustworthy. This work can support important areas like digital security, news verification, and criminal investigations. It will help build a safer and more reliable online world, where people can trust the images they see.

XXIX CYCLE

Simone Carta

Tema di ricerca:

Forgery Detection for the Enhancement of Fingerprint and Iris Recognition Systems.

Abstract

With the increasing deployment of biometric systems for personal authentication and identification, security against spoofing attacks has become a critical challenge. In particular, fingerprint- and iris-based biometric modalities, while offering high levels of accuracy, remain vulnerable to presentation attack techniques, such as the use of silicone fingers, high-resolution images, or printed iris patterns. This work proposes an advanced approach for the automatic detection of biometric spoofing, aimed at enhancing the reliability and resilience of both unimodal and multimodal biometric systems. The proposed methodology moves beyond traditional manual feature extraction of biometric texture, instead leveraging state-of-the-art computer vision and deep learning techniques. These methods have recently demonstrated strong performance in various image-based pattern recognition tasks, with a particular focus on the use of convolutional neural networks (CNNs) trained on realistic datasets containing both genuine samples and spoofing attempts.

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Giuseppe Floris

Tema di ricerca:

Robust Artificial Intelligence for Cybersecurity Applications.

Abstract:

Web applications face evolving and complex threats, such as SQL injection (SQLi), cross-site scripting (XSS), server-side request forgery (SSRF), and privacy attacks, and traditional signature- or rule-based defences struggle to prevent these attacks. For this reason, AI systems are widely employed. These systems learn new patterns and detect vulnerabilities, helping to detect and block attacks that older methods fail to detect. However, this widespread use of AI in highly critical contexts raises issues of reliability, robustness, privacy protection, and potential risks. These threats have the potential to become more sophisticated over time to evade models trained on already known patterns. Consequently, continuous retraining on updated data is necessary, but it introduces the risk of regression, compromising model performance in detecting already known exploits. Furthermore, AI systems for web application security are also vulnerable to adversarial examples, where an attacker imperceptibly modifies the input to cause the model to misclassify, making robustness measures essential to prevent potential exploits. This research focuses on developing robust and reliable machine learning models that can maintain high performance in the cybersecurity domain, even in the presence of manipulated data or unexpected conditions. Specifically, the research explores defence techniques, such as adversarial training (training on adversarial examples), detection of evasion attempts, and the adoption of design strategies oriented towards model robustness. It investigates the integration of such robust models into practical applications for system and network security. In addition, a key part of the work is the systematic evaluation of robustness using adversarial attacks, i.e., the generation of adversarial inputs that allow the identification of residual vulnerabilities and the iterative improvement of proposed defences. The main objective is to ensure the resilience of security AI systems to malicious disruptions while improving their generalization capability to new attack types. This is achieved by analyzing the entire

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pipeline, from input data characteristics to model architecture to evaluation metrics, to understand their interactions and their impact on overall performance. Considering the continuous evolution of web application attacks, performance regression, and robustness against adversarial attacks, the research highlights the complexity of pipelines in cybersecurity and aims to contribute to the development of cybersecurity systems that ensure reliability, resilience, and are able to deal with increasingly sophisticated attacks over time.

Marco Garau

Tema di ricerca:

A Data-Driven "What-If" Analysis to Foster Mode Shift from Private Car to Public Transport Services.

Abstract

Urban growth and increasing demand for mobility are challenging transport planning, which requires increasingly accurate data on mobility patterns to propose effective solutions. This research contributes to addressing this challenge by proposing a model and a practical implementation of "What-If" analysis to support the design of MaaS (Mobility as a Service) systems by integrating crowdsourced mobility demand data and public transport data through GTFS (General Transit Feed Specification). Focusing on the city of Cagliari, we use data obtained from the "IoPollicino" crowdsoucing project to analyse mobility patterns and validate our model. The study introduces several metrics, combining spatial and temporal factors to compare public transport (PT) services with private travel and to identify key PT routes for improvement. The model simulates alternative scenarios to optimise public transport, laying the foundation for sustainable urban mobility using big data analysis technologies. The results reveal the shortcomings of public transport in terms of spatial coverage and timing, demonstrating that many private trips could switch to public transport, ensuring better accessibility and frequency.

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Usama Mahmood

Tema di ricerca:

Development of flexible electronic systems for soft robotics applications.

Abstract

The research activity of PhD student Usama Mahmood is primarily carried out within the framework of the European Project BIOMELD and focuses on the development of flexible electronic systems for the real-time control and monitoring of specific soft robots known as "biohybrid machines." These systems are fabricated on ultra-flexible plastic substrates with a thickness of no more than 2 micrometers, and they include both sensors for monitoring the robot's movement—such as strain sensors—and electrodes for actuating cellular tissues integrated into the robot, which are responsible for its motion. The technology used is organic electronics, mainly involving low-cost, large-area fabrication processes such as inkjet printing.

Luca Martis

Tema di ricercar:

Lightweight Spiking Neural Networks for Edge Computing.

Abstract:

The domain of Edge AI for ultra-low-power wearable devices is a rapidly evolving frontier with significant transformative potential. Within this context, Spiking Neural Networks (SNNs) have attracted growing attention due to their energy-efficient, event-driven computational model, making them particularly well-suited for resource-constrained applications. These networks achieve their best performance on dedicated neuromorphic processors, which are specifically designed to exploit event sparsity and maximize computational efficiency. Currently, several specialized neuromorphic processors, have proven highly effective in executing large-scale SNNs while maintaining impressive energy efficiency. Nevertheless, despite their promise, the widespread adoption of neuromorphic hardware remains limited by high development costs and restricted accessibility. The goal of this project is the development of custom hardware systems for the efficient execution of

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algorithms based on Spiking Neural Networks, offering an alternative to currently available neural accelerators. The aim is to overcome the barriers posed by high development costs and limited accessibility of existing neuromorphic solutions, with a particular focus on integration into ultra-low-power edge devices.

Raffaele Mura

Tema di ricerca:

Safe and Interpretable Artificial Intelligence

Abstract:

Recent advances in generative artificial intelligence, including large language models (LLMs), retrieval-augmented generation (RAG), and multimodal architectures, have enabled systems capable of processing diverse inputs such as images and text to perform sophisticated tasks like conversation, reasoning, and content retrieval. While these models exhibit impressive capabilities, they simultaneously introduce novel and underexplored security and reliability risks. To address these challenges, this research project investigates how subtle and strategically crafted manipulations can compromise model behaviour and evade existing defences. The project examines attack scenarios such as optimized prompt injections, which aim to induce models to produce harmful or inappropriate responses, and data poisoning attacks, which corrupt the knowledge bases of retrieval systems. A significant component of this investigation involves analyzing the internal representations of models, with a particular focus on latent features and embedding spaces. This analysis aims to interpret the model's internal reasoning patterns, uncover how knowledge is organized and decisions are formed, and explore how adversaries might exploit these internal characteristics or how they can be leveraged to enhance model robustness. By systematically exploring these adversarial scenarios, the project aims to expose the limitations of current safety mechanisms and illustrate the ease with which model behaviour can be subverted, often without detection. Through an in-depth examination of these vulnerabilities, the research contributes to a clearer understanding of adversarial threats in generative AI. Ultimately, the objective is to

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provide concrete guidelines toward developing more secure, robust, and reliable machine learning systems capable of resisting adversarial attacks in practical, real-world applications.

Andrea Panzino

Tema di ricerca:

Methods and Models for the Detection of Facial Artifacts Based on Morphing and Deepfakes for the Secure Transmission of ID Document Photos.

Abstract:

In recent years, the use of visual manipulation techniques combined with state-of-the-art deep learning algorithms has raised serious concerns in the field of cybersecurity, particularly regarding the robustness of biometric systems. Among the most critical emerging vulnerabilities is facial morphing—a technique that generates a synthetic face by blending the facial features of two or more real individuals. This manipulation can deceive facial recognition systems, causing them to erroneously validate the same image for multiple identities. Another alarming phenomenon is the rise of deepfakes, which leverage advanced neural networks to create highly realistic but falsified videos, images, or audio recordings, further challenging security systems in distinguishing between genuine and digitally altered content. The aim of this research is to analyze and develop innovative solutions for the detection of such attacks by designing and implementing effective detectors that can be integrated into existing authentication systems.

Diego Soi

Tema di ricerca:

Android Malware Analysis: an in-depth study on analysis, detection and obfuscation techniques.

Abstract:

Nowadays, mobile devices are massively used in everyday activities, not limited to basic operations such as messages, and phone calls but also to security-related tasks like Multi-Factor Authentication (MFA), or unlocking a car, a safe deposit box or access the mobile

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banking. Hence, malicious software poses a great risk to users' security and privacy. These threats are mitigated by anti-malware systems which are often based on Machine Learning, and Deep Learning techniques. Nevertheless, a critical challenge that research needs to address is the increasing variability in terms of behavior of malicious samples. Therefore, this project aims to explore new techniques, to analyze, and represent Android applications in a suitable way for AI-based systems. In particular, the focus is on two core components: interpretability of algorithms, to explain how the underlying model are reasoning; and robustness of detectors against attacks based on traditional obfuscation techniques, e.g. class renaming, and dead code injection, and innovative ones, e.g. steganography to conceal malicious payload.

Bohan Cui (co-tutorship with Xidian University, Xi'an, China.)

Tema di ricerca:

Game-theoretical analysis and synthesis of cyber-physical systems.

Abstract:

With the systems have become more and more networked and open, the perception and decision data are often attacked or tampered by external intruders, which threatens the performance and security of the systems. Therefore, in addition to "system" and "environment" which are concerned by the traditional system supervisory control theory, "adversary", as a new element is increasingly emerging in the analysis and synthesis problem in open interactive environment. It brings new challenges to the research of system analysis and controller synthesis. Therefore, we aim to introduce the idea of game theory into the discrete event systems, depict the interaction between the "system and the "adversary" in the open interactive environment, and synthesis the secure supervisor for this kind of systems. This problem is referred to the supervisory control theory under attack, which has drawn much attention in recent years. However, the basic idea of the above works is based on the assumption that the action pattern of the adversary is known in advance. This model restricts that the adversary cannot adjust its behavior according to the behavior of the

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supervisor. To this end, it is necessary to introduce the idea of game theory into the analysis of discrete event systems and supervisory control theory.

XXXVIII CYCLE

Lorenzo Agostino Cadinu

Tema di ricerca:

Development of a Fluorescence-Based Device and Predictive Algorithm for FMN Monitoring in Machine Perfusion of Human Organs.

Abstract:

Waiting lists for organ transplantation are steadily increasing worldwide, with many patients becoming too ill or dying before receiving an organ. In recent years, machine perfusion has re-emerged as an innovative technique for organ preservation, offering the additional advantage of assessing organ viability prior to transplantation. In this context, Flavin Mononucleotide (FMN) has gained attention as a promising biomarker: its release from mitochondria due to ischemia-reperfusion injury is strongly correlated with post-transplant outcomes. The main challenge lies in the effective and real-time detection of FMN in the perfusion fluid. This PhD project developed an innovative fluorescence-based device capable of detecting and quantifying FMN during the perfusion of various human organs (heart, lung, liver, pancreas, intestine). An integrated advanced algorithm enables not only accurate quantification, but also prediction of future FMN levels and post-transplant outcomes even before transplantation occurs. Clinical tests confirmed the system's reliability and high performance. This work represents a significant step forward toward a more predictive, personalized, and efficient transplantation medicine.

Elena Ferrazzano

Tema di ricerca:

Sensorization of Prosthetic Limb.

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Abstract:

The primary objective of upper-limb prosthetics is to create a device capable of replicating its human counterpart in both aesthetic and functional aspects. Among the key factors influencing the sense of embodiment—and consequently, the acceptance or rejection of the prosthetic limb—is the incorporation of sensory feedback. Through the integration of sensors, it becomes possible to design a prosthetic hand capable of performing strong, multi-finger grasps, as well as fine, precise manipulations with a single finger. Moreover, such integration enables the perception of objects and the restoration of sensory feedback. The goal of sensorization is to provide sufficient information for controlling the prosthesis throughout all stages of the grasping process—namely, approaching the object, making contact, lifting/using, positioning, and releasing—while also enabling tactile feedback to the user. This research project, conducted in collaboration with Prensilia S.r.l., is part of the MAGNELIQ project, funded by the European Union's Horizon 2020 research and innovation programme. Its aim is to develop a novel magnetoelectric (ME) liquid material and to design distributed force sensors for robotics and prosthetics that leverage the unique properties of this material. A magnetoelectric material is characterized by magnetic properties that can be modulated through an electric field, and vice versa. The use of a liquid within the sensor offers several advantages, including increased flexibility compared to solid-state components, allowing sensors to be fabricated in various shapes and sizes. Currently, there are few force sensors that incorporate liquids, and in most of these, the liquid is located near the fingertip, making them fragile; any damage could lead to leakage. The present work aims to develop a force sensor that can be embedded within the prosthesis itself. The sensor comprises a sensing component and a deformable component made of a magnetic elastomer. The deformable component changes shape under external load, which is detected by the sensing element via magnetic interaction. The elastomer acts as a distributed magnet placed above the sensing layer. The sensing component consists of a chamber containing the ME liquid and an array of electrodes.

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Mohammadali Hamidi

Tema di ricerca:

Enhancing User Quality of Experience in Multimedia Environments: Subjective and Objective Approaches for Image and Point Cloud Content.

Abstract:

In the rapidly evolving landscape of immersive media and communication technologies, ensuring a high Quality of Experience (QoE) for end-users has become a central challenge. This research aims to advance the understanding and modeling of QoE in multimedia networks, with a particular focus on complex visual content such as 2D images and 3D point cloud data. The work integrates subjective user studies with the development of objective prediction models to assess and enhance QoE across a variety of media formats and network conditions. Subjective experiments are designed to capture perceptual user ratings under controlled conditions, providing a reliable ground truth for evaluating quality. The datasets include both natural images and projected views of dynamic/static point clouds, processed under various distortion types and levels. On the objective side, machine learning and deep learning models are employed to predict user-perceived quality from visual and network features. These models leverage insights from the collected subjective data and incorporate both handcrafted and data-driven features to improve prediction accuracy and generalization. Ultimately, this research contributes to the design of more user-centric multimedia systems by providing tools and insights for measuring and optimizing QoE in both traditional image content and emerging volumetric formats such as point clouds.

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Nasreddine Makni

Tema di ricerca:

Development of Innovative Sensors for Direct Detection of Plant Water Status to Optimize Irrigation Management.

Abstract:

The agricultural sector, particularly in Mediterranean countries, is facing increasing challenges related to water scarcity, exacerbated by the increasingly evident effects of climate change. In this context, precision agriculture has emerged as one of the most promising strategies to improve water resource management efficiency and enhance crop productivity. However, traditional monitoring tools, such as soil moisture sensors and weather stations, only provide an indirect assessment of plant water needs, often proving insufficient for ensuring truly targeted and efficient irrigation. This doctoral research aims to develop innovative and non-invasive biosensors capable of directly detecting the plant's water status. These devices will provide real-time, highly accurate data on how much and when to irrigate, significantly improving irrigation management. The ultimate goal is twofold: on the one hand, to minimize water waste; on the other, to promote more sustainable and resilient agricultural practices. The proposed sensors represent a tangible advancement in precision agriculture, offering scalable and effective solutions to address current and future environmental challenges.

Gianpaolo Perrelli

Tema di ricercar:

Verification of the Authenticity of Automatic Identification through Physiological and Behavioral Biometrics, Contextual Analysis, and Associated Data Management Techniques.

Abstract:

The authenticity of information has become a critical challenge in recent years. Every day, we rely on digital systems to authenticate ourselves and connect with the world, yet the emergence of techniques to generate hyper-realistic synthetic content threatens this trust. We live in an era where every piece of data is a potential forgery. To protect the integrity of

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systems, it is essential to develop advanced technologies capable of distinguishing between the real and the manipulated, particularly in applications that handle sensitive data. Despite progress in deepfake detection, many solutions overlook a crucial scenario: videos subjected to simple yet widespread transformations, such as automatic compressions applied by social networks. These algorithms remove precisely the information that detectors rely on to identify forgeries, rendering them ineffective in real-world contexts. This research addresses the problem on two fronts: the development of advanced methods to counter deepfakes, even under critical conditions; and the implementation of non-invasive approaches to prevent unauthorized access to devices, leveraging only the sensors integrated in smartphones to automatically and transparently recognize the authorized user.

Giovanni Pettorru

Tema di ricercar:

Next-Generation Location-Based Services: GPS-Free Positioning Solutions for IoT Environments.

Abstract:

In recent years, the scientific community has focused on the challenges of localization, task assignment, and network orchestration within complex IoT environments. In this direction, Location-Based Services (LBS) will play a critical role in enabling intelligent, context-aware solutions that adapt to the operational environment. However, dependence on satellite-based positioning systems like GPS limits the effectiveness of these services, especially in indoor or obstructed areas with poor coverage. This research addresses these challenges by developing GPS-free localization techniques based on Received Signal Strength (RSS) measurements, offering reliable device position estimates in real-world environments without requiring complex infrastructure. A key aspect of this work is the use of hybrid approaches that integrate data from multiple technologies with statistical and heuristic considerations, ensuring robustness against environmental interference as well as network attacks, such as signal manipulation. This approach enhances both the reliability of positioning and the security of position-based decision-making. The proposed solutions are

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being validated in real-world scenarios, with a focus on the Smart Agriculture sector. In these applications, commercial IoT devices are used to monitor environmental parameters and track assets or mobile actuators (e.g., tractors, drones, remote sensors), leveraging low-power communication technologies and ensuring a cost-effective infrastructure. Preliminary results indicate good localization accuracy even in semi-structured, dynamic environments, demonstrating resilience to noise and interference.

Lorenzo Pisu

Tema di ricerca:

Analyzing, detecting, and defending against web vulnerabilities on novel technologies.

Abstract:

With the technological advancement of modern web applications, the risks of attacks on both the server and client sides have increased exponentially. The data and functionalities provided by websites have become increasingly central to our daily lives, spanning from the healthcare sector to the financial industry. Vulnerabilities in these services now represent a powerful tool for malicious actors, who can exfiltrate sensitive data and compromise the functionality of applications, causing damage to businesses and public institutions. Through a systematic analysis of the technologies used by applications, it is possible to identify the risks associated with their use and to define strategies to reduce or mitigate them. By studying attack methodologies, it becomes possible to develop automatic defenses capable of blocking malicious users and preventing them from exploiting potential vulnerabilities. This project focuses on the most recent and cutting-edge technologies which, being still in an early stage of adoption, may present greater risks as they are not yet fully understood. The analysis starts by systematically reproducing vulnerable usage scenarios, with the aim of building methodologies to recognize such scenarios in real-world contexts. In many cases, it is possible to create automated tools capable of detecting vulnerabilities on a large scale, thereby enabling the measurement of the prevalence of specific weaknesses in web applications already deployed in production.

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Cinzia Salis

Tema di ricerca:

Development of a Bidirectional Implantable Neural Interface for Prosthetic Control.

Abstract:

Currently, it is estimated that there are over 40 million amputees worldwide, with approximately 215,000 amputations performed each year due to traumatic events or chronic conditions such as diabetes and cancer. These numbers are expected to rise, compounded by an aging population and the increasing prevalence of diseases like diabetes and cardiovascular conditions. In this context, a particularly promising area of research is focused on improving the quality of life for amputees through the development of advanced prosthetics. These devices aim not only to restore motor function through electromyographic (EMG) signal control but also to restore sensory feedback, with the goal of recreating the sense of touch. In fact, tactile perception is reported by upper-limb amputees as one of the main functions missing in currently available prosthetics, which are often difficult to integrate into daily life due to the high cognitive load required for their use. In the literature, there are primarily two approaches for creating devices with implantable electrodes. The first involves interfacing the nerves with an external device via implanted electrodes connected by transcutaneous wires. This method presents several challenges, as the cables passing through the skin are prone to damage and infections, and the external device is bulky and impractical for daily use. The second approach involves the use of osteointegrated prosthetics, which utilize a titanium channel inserted into the bone for electrode passage, thereby eliminating the need for percutaneous connections. However, this solution is not suitable for a large portion of patients, as conditions such as advanced age, diabetes, and osteoporosis—the leading causes of amputation—prevent osteointegration. Therefore, the proposed research project aims to overcome these limitations through the development of a system consisting of an implantable central communication unit, capable of receiving data and power wirelessly from an external unit and communicating via wired connection with various peripheral neurostimulation and data acquisition units distributed throughout the body. This approach introduces two key

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advancements over the current state of the art. The first is total implantability, which eliminates the risk of infections associated with transcutaneous cables and makes the system more discreet and functional. The second is the use of a distributed architecture, which allows the central unit to be placed at the most surgically accessible point, while the stimulation and acquisition front-ends are positioned directly near the major nerves or muscles to be stimulated or monitored. Additionally, the adoption of front-ends dedicated to acquiring EMG signals through epimisial electrodes (placed directly on the muscle) enables a significant improvement in prosthetic control, making the interaction with the prosthesis more natural and effective.

Davide Sitzia

Tema di ricerca:

Advanced Data Quality Assessment for Synchronized Monitoring in Power Systems.

Abstract:

Research activities focus on improving data quality in electric power system monitoring, with the goal of developing advanced techniques that can also be applied to environmental monitoring and biomedical signals. The core of the work concerns time-synchronized measurements over wide geographic areas in power systems. In this context, Phasor Measurement Units (PMUs) and Merging Units (MUs) are key devices: advanced instruments for real-time observation of the electric grid, whose performance depends not only on hardware quality but also on operating conditions and time synchronization mechanisms. For PMUs, research is devoted to the statistical characterization of measurement errors, aiming to identify the most suitable models to describe their behavior. Furthermore, the integration of synchrophasor estimates with power quality indices is explored, with the goal of providing an indication of the reliability of the measurements. At the same time, MUs are studied as the key element in the IEC 61850 measurement chain, investigating the introduction of intelligent features for automatic event detection, even in noisy or complex scenarios, by leveraging the Matrix Profile (MP) technique. The developed methodologies

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are then extended to other domains that share the challenge of reliable measurement under variable conditions.

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Chenhao Cui

Tema di ricerca:

Safety enhanced and efficient cooperative control of dual crawler cranes under motion constraints.

Abstract:

Crawler cranes are widely used in wind power, chemical, and construction industries, often employed for lifting large equipment such as wind turbine blades and distillation towers. With the continuous development of these industries, the weight and shape of the equipment to be lifted are becoming increasingly complex. For tasks requiring high installation precision, such as wind turbine blade or bridge installation, a single crane is inadequate due to its limited capacity and inability to adjust the load's posture, necessitating the collaboration of two cranes. This collaborative operation significantly increases the complexity and safety risks of the lifting process which typically requires multiple experienced operators to work together. During the operation, the lifting path cannot be precisely planned, requiring constant adjustments near the installation position to complete the task. This approach results in significant uncertainty throughout the process and leads to low efficiency. To achieve this, a high-fidelity mathematical model will be established to characterize the dynamic interactions between dual cranes, payloads, and environmental factors. Leveraging this model, control strategies will be designed to address minimizing the cycle time and the load swing in dual-crane systems.

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Hatami Davood

Tema di ricerca:

Towards cheap, portable and reliable OFET-based biochemical sensors.

Abstract:

Over the past two decades, organic thin-film transistors (OTFTs) have been widely investigated for biochemical sensing applications: from ion-sensitive sensors to enzymatic, immunological, and genetic ones. In this field, largely driven by the demand for low-cost, disposable devices suitable for large-scale screening purposes, various OTFT architectures such as electrolyte-gated organic field-effect transistors (EGOFETs), organic electrochemical transistors (OECTs), and extended-gate organic field-effect transistors (Ex-gate OFETs) have gained significant attention in the scientific community. Although numerous papers have reported remarkable performances and substantial technological progress including the integration of two-dimensional materials and the development of flexible, transparent, and fully printed sensor platforms, these biosensors are still confined to research laboratories. Their limited translation into real-world applications continues to raise concerns regarding the reliability, reproducibility, and consistency of the claimed performance under practical operating conditions.In this thesis, an effort has been made to provide a more realistic assessment of the advantages and limitations of OTFT-based biosensors. Particular attention has been given to addressing key reliability issues that hinder their transition from laboratory research to practical applications. Furthermore, potential strategies are proposed to deal with these challenges, aiming to enhance the stability, the reproducibility, and the overall performances of these devices under real-world conditions.

Tianyu Liu.

Tema di ricerca:

Secure and Reliable Cyber-Physical Systems: Modelling, Opacity Analysis and Timed Fault Diagnosis via Switching Output Automata.

Abstract:

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Cyber-physical systems (CPSs) whose outputs are discrete or quantised piece-wise continuous signals demand modelling formalisms that can simultaneously capture logical behaviour and timing information. Switching Output Automata (SOA) meet this requirement by associating each discrete state with a finite set of possible output values while enforcing a minimum dwell time that prevents Zeno phenomena. This thesis develops an SOA-centred framework that advances two complementary research thrusts: information-flow security, addressed through opacity analysis, and dependability, addressed through fault diagnosis. For security, the thesis first establishes rigorous conditions and algorithms for verifying Current-State Opacity (CSO), ensuring that an external observer cannot infer secret states from observable outputs. The approach relies on the systematic construction of evolution automata and their observers, enabling scalable analysis. The concept is then generalised to timed opacity, in which secrets are defined not only by the global state but also by the dwell time spent in that state. Logical abstractions that discretise time into finitely many intervals preserve all information required for the verification task. For dependability, the work introduces Switching Output Automata with Faults (SOAF) and the associated Evolution Automaton with Faults (EAF). This formalism models faults whose occurrences are constrained to time windows that depend on both the discrete state and the current output. By adapting classical diagnoser synthesis, the thesis derives a timed diagnoser able to detect and isolate such faults. The practicality of SOA-based modelling and CSO verification is demonstrated on a benchmark smart water-supply system, highlighting the framework's potential for security-by-design in real infrastructures. Theoretical results on timed opacity and timed fault diagnosis lay the groundwork for forthcoming experimental validation and integration, ultimately aiming to enhance both the security and reliability of complex CPSs.

Andrea Pitzus.

Tema di ricercar:

"Conception of Deep Learning Methods for the Study of Intracardiac Electrograms to Support Ablation Therapy in Post-Ischemic Ventricular Tachycardia".

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Abstract:

Post-ischemic ventricular tachycardia (piVT) is a leading cause of mortality in Europe and the United States, with an aging population in the Western world that highlights the urgent need for effective preventive and therapeutic interventions. While ablation remains the cornerstone of modern electrophysiology (EP) for treating piVT, this therapy is still hindered by significant limitations, including variability in procedural outcomes due to operator dependency and high recurrence rates. My research project investigated the potential of advanced engineering solutions, in particular deep learning (DL) techniques, to enhance electrophysiological procedures through automated analysis of electrograms. The primary objective was to develop computational tools that support electrophysiologists during piVT ablation, reducing operator dependency, improving procedural precision, and enhancing clinical outcomes.

Gao Jie. (co-tutorship: Northwestern Polytechnic University, Xi'an, China)

Tema di Ricerca:

Research on Facial Video Deepfake Detection Algorithm.

Abstract:

Deepfake technology, which emerged in 2017, is a sophisticated form of facial manipulation that can be used for malicious purposes by altering facial expressions or identities. Numerous "deepfake" applications, such as FakeAPP and ZAO, have become widely available. As Deepfake technology continues to evolve, the generated content is becoming increasingly realistic. These AI-driven technologies offer new possibilities for creating high-quality fake images and videos, posing significant threats to personal privacy, social reputation, and national security. While various Deepfake detection methods have been proposed, there are still unresolved challenges in this field. This highlights the urgent need for effective Deepfake detection techniques to address the serious challenges posed by visual fake content. This Phd focus on Facial Deepfake Detection, specifically addressing

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issues such as compression problems, the generalization of cross-domain cases, and other related challenges. The goal is to alleviate these issues by exploring innovative solutions to enhance the detection of Deepfake content.

Wenjie Zhao. (Co-tutorship: Xidian University, Xi'an, China).

Tema di Ricerca:

Algebraic Connectivity Control and Maintenance with Application to Open Multi-Agent Networks.

Abstract:

The research aims to design distributed protocols to enhance the resilience of time-varying networks against disconnection in Open Multi-Agent Networks. In such open networks, agents can dynamically join, leave, fail, or be subjected to network attacks such as Denial-of-Service (DoS) attacks or False Data Injection (FDI) attacks. The proposed methods based on the self-organization of the network graph structure, utilizing only local information or globally estimated information (including spectral properties of the corresponding Laplacian matrix) obtained via distributed consensus and optimization algorithms. The goal is to optimize the network topology towards a desired structural form with the minimum number of actions. Ideally, the network should maintain high algebraic connectivity while respecting a given desired degree constraint (the number of edges/communication channels per agent). The protocols developed in this research will be applicable to unmanned aerial vehicle (UAV) swarms, large-scale peer-to-peer networks of anonymous users, and large-scale multi-agent networks interacting through communication infrastructures. These methods will significantly enhance the resilience of such systems against disconnections. Furthermore, this research will explore techniques to achieve r-robust graph topologies through self-organization. This will enable the practical application of formal guarantees for the convergence and stability of distributed protocols based on graph-theoretic conditions, where r-robustness is a critical indicator of a networked system's resilience to FDI attacks.

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XXXVI CYCLE

Tenglong Kang. (co-tutorship: Xidian University, Xi'an, China)

Tema di Ricerca:

Fault Diagnosis of Discrete Event Systems Under Sensor Attack.

Abstract:

We investigate the problem of diagnosing the occurrence of a fault event in a discrete event system (DES) subject to malicious attacks. We consider a DES monitored by an operator through the perceived sensor observations. It is assumed that there exists an active attacker that can tamper with the sensor observations received by the system operator. In this regard, we introduce the notion of robust diagnosability against attacks in order to capture the ability of the operator to still diagnose the occurrences of faults in the case of attacks. To verify it, we propose the notion of a verifier and a joint diagnose under attack, based on which a necessary and sufficient condition for robust diagnosability is presented. It is shown that the proposed approach based on the verifier requires polynomial time with respect to the number of states and events of a system. On the other hand, compared with the verifier under attack, the joint diagnose can be used to check whether an attacker can keep undiscovered from the system operator, i.e., maintain stealthy. The refined diagnoser, called a stealthy joint diagnoser, provides a necessary and sufficient for the existence of a successful attacker, which can destroy diagnosability and meanwhile keep stealthy.

Kun Peng. (co-tutorship: Xidian University, Xi'an, China)

Tema di Ricerca:

Synthesis approach for opacity enforcement by supervisory control and editing function.

Abstract:

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Opacity is a crucial property in security-sensitive systems, preventing unauthorized inference of confidential information. In a discrete event system (DES), the secret information can be categorized into a set of states and a language, which classified the property into state-based opacity and language-based opacity, respectively. Varies kinds of state-based opacity include initial-state opacity, current-state opacity, initial-final opacity, K-delayed-state opacity, and infinite-state opacity are defined according to the types of secret state or the timeliness of confidential information. The kinds of opacity mentioned above can be transformed into current-state opacity, which is the simplest one to verify and enforce by corresponding types of secret monitors. By constructing the current-state observers of the monitors, we can verify whether the original plant satisfies the required kind of opacity. If not, we can search for the language that violates the kind of opacity. To enforce the plant opacity in the original plant, we can adopt the method of supervisory control to disable these behaviours or corrupt the observation of an intruder to prevent them from inferring these behaviours. For a more practical case, there exists a set of controllable events, a set of erasable events, and a set of insertable events, which implies that some illegal behaviours cannot be disabled or edited, and the opacity enforcement cannot be realized by adopting supervisory control or editing functions only. We synthesis the two methods to propose a novel approach to meet more cases.

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