XAI to satisfy safety requirements of B5G V2X infrastructure (PhD

Discipline : Informatic / Computer Sciences

Line Manager: Sylvain Lecomte

Workplace: Lille (Villeneuve d'Ascq)

Type of contract and duration: CDD – 36 months

CONTEXT :

Public establishment belonging to IMT (Institut Mines-Télécom), placed under the supervision of the Ministry of Industry, IMT Nord Europe has three main objectives: providing our students with ethically responsible engineering practice enabling them to solve 21st century issues, carrying out our R&D activities leading to outstanding innovations and supporting territorial development through innovation and entrepreneurship. Ideally positioned at the heart of Europe, 1 hour away from Paris, 30 min from Brussels and 1h30 from London, IMT Nord Europe has strong ambitions to become a main actor of the current industrial transitions, digital and environmental, by combining education and research on engineering and digital technologies.

Located on two main campuses dedicated to research and education in Douai and Lille, IMT Nord Europe offers research facilities of almost 20,000m² in the following areas:

- Digital science,
- Processes for industry and services,
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The position is vacant within the Centre for Education, Research and Innovation (CERI) Digital Systems. It covers a wide disciplinary field linked to constrained systems (the Internet of Objects, robotics), Humans (and in particular their interactions with the digital world) or even complex systems through the prism of Artificial Intelligence and Automation. The 34 lecturer-researchers and 6 engineers at CERI are able to cover all teaching fields in the field of digital sciences and technologies (Data, Artificial Intelligence, Telecoms, Networks, Systems, Applications, Cybersecurity, etc.). It is structured around 3 research groups: ARTS (Autonomous Resilient Systems), HIDE (Human, Interaction, DEcision) and McLEOD (Modelling and Control of Complex systems in Large Environments requiring Optimized Decision).

BRIEF:

The thesis will be carried out within the framework of the ANR "TRAVEL" project, which aims to propose an eXplainable Artificial Intelligence (XAI) framework to explain the logic behind the black-box model behaviors trained on data related to vehicular communications (V2X) and allowing to improve the communication network infrastructure at various levels (PHY, SDN, and NFV), thus ensuring a safe and efficient deployment.

The ICT infrastructure is becoming increasingly complex and interdependent due to rapid virtualization, softwarization, data massification, and cloudification. With the widespread deployment of wireless networks, intelligent and automated network operation is becoming increasingly essential, deserving tremendous research effort. AI holds significant potential for application in the network field (AI for IT operations), promising improvements in operational efficiency, Quality of Service (QoS), and Quality of Experience (QoE), along with reductions in operational costs and complexity **[1]**. Achieving network self-maintenance and self-healing capabilities is also a major concern. This entails effectively integrating cross-layer anomaly detection, root cause analysis, explainability, and response into a closed-control loop, guided by the output of root cause

analysis and predefined policies to restore system performance. This necessity for intelligent network operation coincides with the ongoing evolution of cellular technologies, notably the progression from 5G to what is anticipated as 6G.

Despite the excellent performance of AI models on enormous tasks in V2X Infrastructure, when their decisions cannot be well-interpreted, it is difficult to trust them. In recent years, the proliferation of AI applications in network communications and cybersecurity with the requirements of the European Commission for algorithms to provide explanations to users has reinforced the necessity of employing XAI in this field. Indeed, the advent of 5G specifically carries the ambition of a very wide coverage, including outside cities. Combined with paradigms such as Software Defined Networking (SDN) and Network Function Virtualization (NFV), 5G is expected to enable faster access and high scalability of both devices, services, applications and data, and thus eventually establish itself as the mobile communication system for all applications in the smart city, including V2X communications **[2]**. The thesis's works will be applied on the 5G Core Network (5G-CN) and its interfaces with the 5G-RAN. It aims to develop XAI approaches to network slicing automation at the interface between the 5G-CN and the 5G-RAN **[3]** to allow a deployment of AI-assisted sliced networks in V2X infrastructure in a way that satisfies safety constraints. Indeed, V2X infrastructure is a critical domain which involves human lives, and in which any flaw may have dramatic consequences. Therefore, any malfunction must be anticipated, and anyhow completely auditable **[4]**. To achieve this goal, this thesis will develop XAI methods that rely on the theory in the domain of V2X infrastructure for providing better explanations. That will be made both during data collection and feature engineering phases. In fact, a scientific theory represents a well-founded and widely accepted statement, hypothesis, or explanation that has withstood rigorous testing and scrutiny **[5]**. We will also explore local interpretability techniques to explain local inference of AI models regarding V2X infrastructure safety requirement parameters by providing alternative or counterfactual scenarios for the explained scenarios. Those techniques will help us for each scenario to explain, find its most similar scenario measured by a chosen distance metric, but that has an opposite AI inference.

The objectives of this thesis are:

- Explore the current state-of-the-art XAI approaches in the field of V2X infrastructure.
- Develop XAI schemes based on existing theory in the field of V2X infrastructure
- Integrate V2X infrastructure and application safety requirements into the XAI architecture.

REQUIRED PROFILE :

Interested candidates should meet the following criteria:

- M.Sc. degree (or equivalent) in Computer science or related discipline,
- Strong background in Artificial Intelligence/Machine Learning with, if possible, experience in eXplainable Artificial Intelligence
- Experience in the field of communication networks would be an undeniable advantage
- Good programming skills (Python, Java, C++),
- Good written and communication skills in English.
- Ability to organize and manage priorities in order to meet deadlines

CONDITIONS :

The position is set to start on November 1st, 2024, for a period of 36 months (temporary contract).

INFORMATION AND APPLICATION METHODS :

Contact: **Dr. Jerry Lonlac** jerry.lonlac@imt-nord-europe.fr **Pr. Patrick Sondi** patrick.sondi@imt-nord-europe.fr

DEADLINE DATE FOR SUBMISSIONS : September 30 th, 2024

References

[1] Q. L. Y Dang and P. Huang, "Aiops: real-world challenges and research innovations," IEEE/ACM 41st ICSE, 2019
[2] M. Wahl and P. Sondi,. "Conception et Évaluation de Protocole de routage ad hoc", ISTE, 2023.
[3] P. Barnard et al., "Resource Reservation within Sliced 5G Networks: A Cost-Reduction Strategy for Service Providers", IEEE ICC, 2022.
[4] C. Zidi, et al. "Review and Perspectives on the Audit of Vehicle-to-Everything Communications," IEEE Access, 2023
[5] R. Richard, et al., "Philosophy of social science", Oper. Manag., 1968.