Project objectives

In the architectural domain of future 6G communication networks, there is a need for full integration and interoperation between satellite, aerial and terrestrial network components, merged in a unique dynamic-adaptive network infrastructure denoted as the 3D network. Within this architecture, the evolution of mobile communications needs a combination of several innovative and complementary advances at the physical layer (PHY), medium access control (MAC), and radio resource management (RMM) that may be optimised with the use of Artificial Intelligence (AI) and Machine Learning (ML).

With these goals in mind, the project on "Physics-based wireless AI providing scalability and efficiency" (PASSIONATE) will unlock ML for wireless by customising and accounting-by-design the unique properties ("physics-based") of the networks they are applied to. Physics-based ML is, in addition, the suitable approach to ensure the scalability, generalisation, reliability, and user trust of ML, enabling ML solutions that are technically robust and possibly explainable-by-design.

Research to be carried out

In full agreement with the CHIST-ERA call "Machine Learning-based Communication Systems, towards Wireless AI", PASSIONATE will accelerate the path towards relevant Wireless AI by successfully integrating software-based solutions (algorithms and simulations) and hardware-oriented proof-of-concepts (developed with software-defined radios). By developing novel physics-based AI/ML to optimise the future wireless network, the project addresses the following topics specified in the call. PASSIONATE will design and apply AI/ML-enhanced techniques to the physical layer and resource optimisation of Radio Access Networks, including MIMO processing and beamforming. AI/ML will also be applied to improving spectrum sensing, a key ingredient of Cognitive Radio. Energy efficiency will be one of the optimisation criteria and targeted Key performance Indicators (KPIs) and the rationale behind some of the techniques that will be implemented, such as the Reflecting Intelligent Surfaces (RIS). Also, one of the advantages of the physics-based approach is that it will provide trustworthy and reliable AI. The combination of software and hardware allows the synthetic data that will be generated for ML training to be validated with measurements, rendering it more reliable and fitted to reality. The data, algorithm descriptions, and code will be shared in open access to facilitate the reproducibility of the experiments, and we will contribute to enhancing some of the open access simulators that are already available. The research will be guided by the definition of use cases that can take advantage of these technologies.

Motivation

Mobile communications have changed, and will continue to change our lives. With 5G under deployment, the interest of the scientific and industrial communities has started focusing on the future 6G communication networks, which will require more advanced capabilities. Achieving new challenging requirements calls for a paradigm shift that the project PASSIONATE will be advancing.

Expected results and impact

In PASSIONATE, we will develop the understanding and vision of what the application of AI/ML to the wireless network can provide and design use cases that can take advantage of this technology. For these use cases and with the new physics-based AI/ML tools, we will design new PHY, MAC, and RRM techniques and algorithms that achieve the ambitious goals of future mobile networks regarding coverage, data rate, latency, and energy consumption. We will evaluate experimentally by realistic simulations and measurements the achieved gains and contribute to creating data sets that can be used for the community. By advancing the state of the art and stimulating research and technology-based innovation through dissemination, PASSIONATE will create awareness and facilitate the positive impact of advanced wireless communications on society and the economy.