Job vacancy #2023-06773

Internship Deep learning techniques for radio identification (possibility of PhD afterwards)

Contract type: Internship agreement

Level of qualifications required: Master's or equivalent

Other valued qualifications: Engineer degree, master degree

Function: Internship Research

About the research centre or Inria department

The Inria research centre in Lyon is the 9th Inria research centre, formally created in January 2022. It brings together approximately 300 people in 16 research teams and research support services.

Its staff are distributed at this stage on 2 campuses: in Villeurbanne La Doua (Centre / INSA Lyon / UCBL) on the one hand, and Lyon Gerland (ENS de Lyon) on the other.

The Lyon centre is active in the fields of software, distributed and high-performance computing, embedded systems, quantum computing and privacy in the digital world, but also in digital health and computational biology.

Context

With the popularisation of software defined radios (SDRs), an malevolent actor can deploy radio systems for interfering with legitimate communications, communicating on unlicensed bands and listening to private communications. In this proposed PhD work we target in a first moment spectrum sensing capabilities, that can be used to automatically locate and classify opponent transmissions, characterising it in terms of center frequency, occupied bandwidth, activity pattern, modulation and coding schemes, frame structure and more. Then we will study the identification problem, trying to uniquely single out individual transmitters among all transmitters. The proposed work will (i) create good datasets to train and test systems for spectrum sensing and (ii) develop deep learning (DL) systems for spectrum sensing/classification and identification.

Nowadays, spectrum surveillance is mainly done with relatively simple systems that require intense human intervention. However, as radio communications systems grow more and more complex in nature and can span larger portions of the spectrum, relying on human-based surveillance risks missing out on improper use of the spectrum. Sophisticated means to detect these transmissions, identify them and locate their source is thus necessary, but remains a complicated task to accomplish.

Assignment

REMARK: This internship can lead to a PhD offer, that shall start October 2024

Concerning the detection of a radio signal, techniques such as energy detection (ED) [1], cyclostationary detection (CD) [2], matched filter (MF) [3] and random matrix detectors (RMD) [4] have been proposed before, but each carry their own set of problems such as a minimal signal-to-noise ratio requirement for the ED, and cyclic features for the (CD), just to cite a few. Detecting a signal becomes more challenging when incomplete observation and/or ultra-wideband signals are present [5], which usually spread the transmitted power over a large bandwidth. After a signal has been detected, extracting its characteristics is even a harder task, requiring most of the times, achieving a partial decoding of the target signal and work only for a limited number of kinds of signals at a time. In this work we aim at using deep learning (DL) techniques to jointly address the spectrum sensing and signal classification problems. DL techniques are more adapted to these kinds of problems due to their nature and require no prior knowledge on the signals and their structures.

The main objective of this internship is to provide DL models to deal with the spectrum sensing/transmission classification problem that are able to perform well in a realistic scenario where challenging channel characteristics exist as well as interference. These DL models can be integrated into a device based on one (or more) SDRs to provide automated detection and characterisation of transmissions, requiring little to none human intervention, and alert law enforcement when stray radio transmissions are detected.

Using DL for spectrum sensing/transmission classification is not new and has been studied before (i.e. [6], [7] and [8]), however we think we can effectively contribute to the subject due to (i) our ability to produce high quality datasets which will be carefully designed, validated and tailored to training DL
models using the CorteXlab testbed, as well (ii) as our prior experience with DL models for radio. Concerning transmitter identification, aside from using identification fields in packets which are very easily impersonated, we rather base identification through radio fingerprinting, using the transmitter characteristics that are imprinted onto the signal are used to identify the transmitter, much like how we can recognise different people through the tone of their voice. Even though this has been studied before (i.e., [9]), many of the works are plagued with problems like identification through channel characteristics (which are dependent on the position of the radios) or synthetic RF imprinting, and ill-created datasets, like the one in [9], which uses synchronisation to orchestrate the transmissions (we have already shown in [10] that the use of synchronisation biases the dataset).

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Main activities

Main activities may include:

- Exploit the current mathematical models and theory concerning spectrum sensing/transmitter classification and transmitter identification to provide a design for both the dataset creation and DL models to be used.
- Create high quality datasets, different from the ones currently available in the literature, for spectrum sensing and transmitter classification.
- Create DL models starting from semantic segmentation ones and evolving toward complex radio situations including partially observed signals (in time and frequency) as well as interfering signals.
- Implementation and experimentation on CorteXlab.

Additional activities:

- High quality papers and report writing
- Seminars and internal collaboration within the team MARACAS

Skills

Technical skills and level required: machine learning (at least basic), probabilities and statistics (basic), signal processing (intermediate), scientific programming in Python - scipy, matplotlib, numpy, panda, xarray (intermediate).

Additional values: digital communications, expertise in programming with tensor flow or PYtorch

Languages: English, French (optional)

Relational skills: hability to collaborate, to communicate with pairs. Strong motivation, enthusiastic, curious.

Benefits package
- Subsidized meals
- Partial reimbursement of public transport costs
- Possibility of teleworking (after 6 months of employment) and flexible organization of working hours
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities

**Remuneration**

Minimum legal gratification

**General Information**

- **Theme/Domain**: Networks and Telecommunications
- **System & Networks (BAP E)**
- **Town/city**: Villeurbanne
- **Inria Center**: Centre Inria de Lyon
- **Starting date**: 2023-02-01
- **Duration of contract**: 6 months
- **Deadline to apply**: 2023-11-12

**Contacts**

- **Inria Team**: MARACAS
- **Recruiter**: Sampaio Leonardo / leonardo.sampaio-cardoso@inria.fr

**About Inria**

Inria is the French national research institute dedicated to digital science and technology. It employs 2,600 people. Its 200 agile project teams, generally run jointly with academic partners, include more than 3,500 scientists and engineers working to meet the challenges of digital technology, often at the interface with other disciplines. The Institute also employs numerous talents in over forty different professions. 900 research support staff contribute to the preparation and development of scientific and entrepreneurial projects that have a worldwide impact.

**The keys to success**

You are pursuing your master level, with a background in machine learning. You want to apply your skills in the field of signal processing and communications.

Fingerprinting, signal identification are tasks of primary interest in the civil context as well as the military one. You want to develop a technique able to detect suspicious signals, unknown waveforms, or any other signal signature in a time-frequency space? This job is for you.

You want to play with mathematics, machine learning, signal processing and experimentation? And why not developing a new technique that would lead to a revolutional product at the end of your internship? This is for you!

**Warning**: you must enter your e-mail address in order to save your application to Inria. Applications must be submitted online on the Inria website. Processing of applications sent from other channels is not guaranteed.

**Instruction to apply**

Applications must be submitted online on the Inria website.

Processing of applications sent by other channels is not guaranteed.

**Defence Security**: This position is likely to be situated in a restricted area (ZRR), as defined in Decree No. 2011-1425 relating to the protection of national scientific and technical potential (PPST). Authorisation to enter an area is granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated in a ZRR would result in the cancellation of the appointment.

**Recruitment Policy**: As part of its diversity policy, all Inria positions are accessible to people with disabilities.