PhD Position F/M [Campagne Doc MI-NF-LYS-2024].
PhD - Deep learning techniques for radio identification

Le descriptif de l’offre ci-dessous est en Anglais

Type de contrat: CDD
Niveau de diplôme exigé: Bac + 5 ou équivalent
Autre diplôme apprécié: engineer degree, master degree
Fonction: Doctorant
Niveau d'expérience souhaité: Jeune diplômé

A propos du centre ou de la direction fonctionnelle

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.

Contexte et atouts du poste

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.

Mission confiée

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 fo 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 thesis 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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**Principales activités**

**Main activities :**

- 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
- Presentations at national and international conferences
- Seminars and internal collaboration within the team MARACAS

**Compétences**

Technical skills and level required : machine learning, probabilities and statistics, signal processing, programming in C/Python.

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

Languages : English, French (optional)

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

**Avantages**

- Subsidized meals
- Partial reimbursement of public transport costs
- Leave: 7 weeks of annual leave + 10 extra days off due to RTT (statutory reduction in working hours) + possibility of exceptional leave (sick children, moving home, etc.)
- Possibility of teleworking (90 days / year) and flexible organization of working hours
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities
- Access to vocational training
- Social security coverage under conditions

**Rémunération**

1st and 2nd year: 2 100 euros gross salary / month

3rd year: 2 190 euros gross salary / month

**Informations générales**

- **Thème/Domaine :** Réseaux et télécommunications
  Système & réseaux (BAP E)
- **Ville :** Villeurbanne
- **Centre Inria :** Centre Inria de Lyon
- **Date de prise de fonction souhaitée :** 2024-10-01
- **Durée de contrat :** 3 ans
- **Date limite pour postuler :** 2024-04-19

**Contacts**

- **Équipe Inria :** MARACAS
- **Directeur de thèse :**
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**A propos d'Inria**

Inria est l'institut national de recherche dédié aux sciences et technologies du numérique. Il emploie 2600 personnes. Ses 215 équipes-projets agiles, en général communes avec des partenaires académiques, impliquent plus de 3900 scientifiques pour relever les défis du numérique, souvent à l'interface d'autres disciplines. L'institut fait appel à de nombreux talents dans plus d'une quarantaine de métiers différents. 900 personnels d'appui à la recherche et à l'innovation contribuent à faire émerger et grandir des projets scientifiques ou entrepreneuriaux qui impactent le monde. Inria travaille avec de nombreuses entreprises et a accompagné la création de plus de 200 start-up. L'institut s'efforce ainsi de répondre aux enjeux de la transformation numérique de la science, de la société et de l'économie.

**L'essentiel pour réussir**

You are a young master or engineer, 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 PhD ? This is for you !

**Attention :** Les candidatures doivent être déposées en ligne sur le site Inria. Le traitement des candidatures adressées par d'autres canaux n'est pas garanti.

**Consignes pour postuler**

Applications must be submitted online on the Inria website.

Processing of applications sent by other channels is not guaranteed.

**Sécurité défense :**

Ce poste est susceptible d’être affecté dans une zone à régime restrictif (ZRR), telle que définie dans le décret n°2011-1425 relatif à la protection du potentiel scientifique et technique de la nation (PPST).
L’autorisation d’accès à une zone est délivrée par le chef d’établissement, après avis ministériel favorable, tel que défini dans l’arrêté du 03 juillet 2012, relatif à la PPST. Un avis ministériel défavorable pour un poste affecté dans une ZRR aurait pour conséquence l’annulation du recrutement.

**Politique de recrutement :**
Dans le cadre de sa politique diversité, tous les postes Inria sont accessibles aux personnes en situation de handicap.