Apprentissage profond pour égalisation de signaux discrets fortement brouillés

Mots clés : Intelligence Artificielle, Sécurité, Couche physique, Communications furtives

Traditionnellement, les systèmes de radiocommunications tactiques utilisent les techniques à étalement de spectre afin d'assurer une certaine sécurité de la couche physique [1,2]. En particulier, les techniques à étalement de spectre par séquence directe (DSSS) sont largement utilisées (e.g. satellites, drones, avions de chasse, sous-marins ...) afin d'assurer une certaine discrétion ainsi qu'une robustesse aux brouillages hostiles. Toutefois, le niveau de discrétion et de protection aux brouillages du DSSS s'est considérablement amoindri durant la dernière décennie, du fait notamment de l'augmentation de la puissance de calcul et de l'émergence d'algorithmes permettant l'apprentissage. Pour mieux protéger les communications tactiques, plusieurs méthodes ont été proposées récemment dans la littérature [3,4,5,6] afin de réduire ainsi le risque de détection [7].

Néanmoins, à cause des incontournables interférences entre symboles qui caractérisent ces signaux tactiques, une égalisation à haute performance est requise du côté du récepteur [2] ; bien que celle-ci requiert une grande capacité de calcul avec un impact considérable sur l'architecture du récepteur, ses performances ne sont pas toujours satisfaisantes, et notamment dans les conditions critiques dans lesquelles les systèmes tactiques sont amenés à se trouver : attaques par brouillage puissant, fort décalage Doppler variable dans le temps nécessitant une grande capacité d'adaptation du côté du récepteur [8,9]. L'objectif principal du stage est donc de concevoir, en utilisant les méthodes d'apprentissage profond, un algorithme permettant l'égalisation de signaux discrets dans des conditions de communications critiques.

Contexte : Ce stage se déroulera au laboratoire U2IS de l'ENSTA sur le campus de l'Ecole Polytechnique à Palaiseau. Il devrait déboucher sur une thèse de doctorat avec rémunération intéressante à l'Institut Polytechnique Paris, qui mettra en œuvre des techniques de communications numériques sans fil, de traitement statistique du signal et d'intelligence artificielle. Les résultats intéresseront la DGA (Direction Générale de l'Armement) et un acteur industriel majeur du déploiement des réseaux tactiques sans fil.

Contacts : tarak.arbi@ensta-paris.fr, benoit.geller@ensta-paris.fr

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Deep learning for heavily jammed discrete signals equalization

Key words : Artificial Intelligence, Security, Physical layer, Stealth communications

Traditionally, tactical radio communication systems use spread spectrum techniques to ensures a certain level of physical layer security [1,2]. In particular, Direct Sequence Spread Spectrum techniques (DSSS) are widely used (e.g. satellites, drones, fighter aircrafts, submarines ...) in order to ensure some discretion, as well as robustness to hostile jamming. However, both the level of discretion and of protection against interference of the DSSS has considerably diminished during the last decade, due in particular to the increase in computing power and the emergence of algorithms allowing learning. To better secure tactical communications, several methods have recently been proposed in the literature [3,4,5,6] in order to reduce the detection risk [7].

Nevertheless, because of the unavoidable inter-symbol interference that characterizes these tactical signals, high performance equalization is required at the receiver side [2]; although it requires a large computing capacity with a considerable impact on the receiver design, its performance is not always satisfactory, especially in critical conditions that tactical systems have to face: heavy jamming attacks, large and time-varying Doppler shift requiring a considerable adaptation capacity at the receiver side [8,9]. The main goal of the internship is therefore to design, using deep learning methods, an algorithm allowing the equalization of discrete signals under critical communications conditions.

Context : This internship will take place at ENSTA's U2IS laboratory on the Ecole Polytechnique campus in Palaiseau. It may lead to a PhD thesis with a competitive salary at the Institut Polytechnique Paris, which should put forward several digital wireless communications, statistical signal processing and artificial intelligence algorithms. The results will be of interest to the DGA (Direction Générale de l'Armement) as well as to a major industrial actor in the deployment of tactical wireless networks.

Contacts : tarak.arbi@ensta-paris.fr, benoit.geller@ensta-paris.fr

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