PLATH Group

ARTIFICIAL INTELLIGENCE FOR RADIO SIGNALS EXPLOITATION

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Artificial intelligence (AI) has long been on the rise in a variety of fields. In automatic image and speech recognition, for example, AI has been performing very well for years and has made modern, more sophisticated applications in the field possible. For this reason, we at PROCITEC GmbH began some time ago to investigate and successfully apply AI techniques as part of the further development of our Communications Intelligence (COMINT) and Radio Reconnaissance solutions to suit our customers Capability Development (CAPDEV) needs.

AI is very often based on the machine learning (ML) approach. Here, an algorithm learns independently to perform a task when the task's solution path is not predetermined; the algorithm finds the solution itself through a special learning phase.

ML achieved a major breakthrough with the application of Deep Neural Networks (DNN). These can now solve increasingly complex tasks through so-called Deep Learning (DL). These DNNS deliver very good results, particularly in the areas of signal-classification and pattern recognition.

Primary steps during the automatic prosecution of a Signal Of Interest (SOI) are detection and classification of the SOI's signaling characteristics. Therefore, it is advantageous to apply neural networks also for these types of auto-tasking. Numerous proposals to achieve this can be found in academic publications. Very often these classification approaches are proposed for use in the field of Cognitive Radio Systems, where, primarily, tasks such as Spectrum Interference Monitoring and Dynamic Spectrum Access are to be

solved.

The core techniques and procedures for radio signals exploitation do not only include the detection and classification of signals. Detection and classification are the initial steps on the way to extracting signal content
and therefore should not be considered in isolation. The full signals exploitation process can be roughly divided into the following steps:

- Detection of SOIs
- Classification of SOIs
  - Determination of the modulation type
  - Determination of the transmission protocol
- Demodulation and decoding
  (extraction of the signal content)

Upon detection of individual SOIs, classification is then performed. The modulation type and transmission protocol of the signal are determined. If these are known, the signal can be demodulated and decoded.

Classification can be based on ML approaches or, classically, by defining and directly measuring characteristic parameters of the individual modulation typos or transmission methods. The latter approach is often termed 'Expert System'.

At PROCITEC, we have been applying the processes described here in our software products to enable the prosecution of radio signals for many years. So far, we have successfully relied on the Expert System approach for the classification of SOIs. In the course of further development and continuous improvement of our products, we have now started to integrate DNN- based approaches into the signals exploitation processes.

As a first step, for modulation types not yet supported in our software, we examined whether DNN-based classification leads to good results and how it can be integrated into the existing process in parallel with our expert system. The basis for this was formed by approaches referenced from previously mentioned documentation.

A crucial challenge in using a DNN is to provide statistically meaningful signal examples in sufficient numbers for its learning phase ("training'). Since in a DNN the decision for a classification, in contrast to the expert system, is not transparently traceable, great care must be taken to determine which characteristic properties the training data set contains and whether these data reflect reality.

In addition, when generating the data set, it is important to selectively vary certain signal parameters (e.g, noise, frequency offset,
etc.) so that the DNN can later respond robustly to such variations in the signals in real-world applications. It has been shown that a sufficient data set can only be generated with reasonable effort using artificial signals.

Based on training data generated in this way, we succeeded in training a DNN and evaluating it for SOI-classification using real radio signals. The work was carried out in close cooperation with a local university.

Subsequently, the new DNN was integrated into our existing software. Great attention was paid to the interaction with the existing software components during the integration process. After successful quality tests,
PROCITEC's go2signals products now feature our first AI-based signal classifiers.

The experience from the development described here has shown that the use of DNNS for the classification of radio signals has very large potential. Therefore, we will continue to push this capability-development initiative at PROCITEC and consider that a balanced combination of the proven classical Expert System' approach and these newer AI-based technologies will deliver even more effective classification results for our customer and end-user communities.

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