Deep Learning in Wireless Communication

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Abstract: Among the most important applications of Deep Learning (DL) to engineering are those in wireless communication (WC). WC concerns the processing, communication, and transfer of data performed between two or more devices that are not connected by an electrical conductor. Considering the constantly increasing volume of devices being deployed, the wireless ecosystem is getting saturated. This poses new challenges to WC, since frequency band allocation needs to move from static to dynamic, in order to try to optimize spectrum occupancy. There have been several recent works in the literature which use DL to predict radio frequency spectrum occupancy. In this poster presentation, we will concentrate on the analysis of DL algorithms for spectrum occupancy prediction in interfering wireless systems, using simulated data. Future work will address the problem of spectrum occupancy with real-time data from the metropolitan Fort Wayne area.

Wireless Communications

It is a method of transmitting informationfrom one point to another, without wires.

Deep Learning...

...tries to mimic the functionality of the human brain, re-organizing the information through several layers ("depth") of filtering so that a computer can provide the essential answers ("learning") to the task of interest. Due to the complexity of this simulated brain structure, this procedure requires the computational power now available. Deep Learning has revolutionized several research fields in the past ten years and is producing an explosion of state-of-the-art results [3]. It is and will continue to play a crucial role also in Wireless Communications

Dataset Description

We analyzed a benchmark dataset of both synthetic simulated channel effects and over-the-air recordings of 24 digital and analog modulation types [1]. Data are stored in hdf5 format as complex (IQ) floating point values. The dataset includes about 2.5 million time series, each containing 1024 time instants.

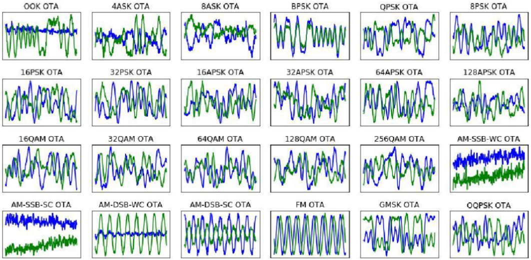


Figure: Examples of the 24 modulation types in time domain vs I/Q

GOAL: Spectrum Occupancy Prediction

The wireless ecosystem is getting saturated and frequency band allocation needs to become dynamic in order to optimize spectrum occupancy and satisfy current needs. We propose to use tools of data science and deep learning to attack the Spectrum Occupancy Prediction problem [4]. Our first assessment concerned the prediction of the modulation type, given the time series observed. The problem is not trivial, especially in the presence of multiple co-existing systems.

Shallow & Deep Time Series Analysis

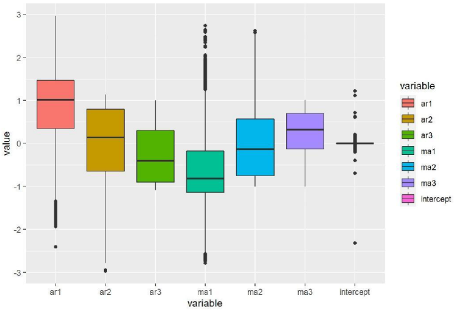
A time series $\{Y_t\}_t \in T$, follows an ARMA(p,q) process if

$$Y_t = \psi_1 Y_{t-1} + \psi_2 Y_{t-2} + \dots + \psi_p Y_{t-p} + e_t - \theta_1 e_{t-1} - \dots - \theta_q e_{t-q}$$

with $e_t t \in T$ is white noise with $Corr(e_t, Y_s) = 0$ for every $s < t$, and parameters $\theta_1, \dots, \theta_q$; $\psi_1, \dots, \psi_p \in \mathbb{R}$

Classical Time Series

We modeled the IQ time series using ARMA(3,3), ARMA(0,6) and ARMA(6,0). These models do not reach the prediction accuracy of deep models, but provide useful interpretations. Below is a box plot, depicting the significance of some of the ARMA(3,3) coefficients (ar1, ar2, ar3, ma1, ma2, ma3) of the 256 QAM modulation type



References

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