Machine Learning Classification of Wireless Communication Signals

Lucy Song, Jayden Booth, Ahmed Ewaisha, Andreas Spanias, Cihan Tepedelenlioglu
SenSIP REU, School of ECEE, Arizona State University

***Abstract*—The ability to differentiate between various wireless communication systems such as 4G networks can be especially important in cognitive radios and in decoding unknown transmissions for military applications. While the technology exists to do this manually, machine learning could significantly increase the identification process's efficiency. In this REU study, we explore signal processing in terms of machine learning and its ability to enhance the analyzation and classification of transmissions. Specifically, our goals are to assemble LimeSDR radios featuring multiple-input-multiple-output (MIMO) systems and use MATLAB programming to process received signal data.**

Keywords—machine learning, LimeSDR, cognitive radio, classification, wireless, MIMO, 2G, 3G, 4G, artificial intelligence

I. INTRODUCTION

Wireless communication has grown considerably since the First Generation (1G) systems of the 1980s. In order to keep up with the growth of data traffic, it is becoming increasingly important to not only develop more efficient technologies that are perceptive and reconfigurable, but also create applications of artificial intelligence (AI) that generate more accurate decision-making and signal classification [1, 2, 4]. Unlike civil applications of wireless communication in which specific transmission schemes or standards are known and assigned to both the transmitted (Tx) and received (Rx), in military applications the standards are generally unknown and thus classification techniques are important and necessary in decoding signals. Without first classifying them, they remain undecodable and useless.

Currently, machine learning, a type of AI, is being used to analyze patterns in wireless communication, including spectrum performance and radio configurations, to improve and optimize the quality of service (QoS) of transmissions [1, 2]. The use of multiple antennas in multiple-input-multiple-output (MIMO) systems are also beneficial in increasing the transmission rate or reducing the bit error rate [3]. A research lab in Chongqing, China has been working closely with the feature recognition (FB) method of machine learning, a Wireless Signal Classification (WSC) algorithm, and higher-order cumulants (HOCs) of received signals in Automatic Modulation Classification (AMC) to distinguish between a variety of modulations [4].

The FB method is only one of two different AMC algorithms. The other is the likelihood-based (LB) method, but it is regarded as more complex and less efficient because it requires more prior knowledge of the transmitted signal [4, 5]; this is rather impractical, especially for military applications that interact with signals featuring unknown characteristics. The FB method requires less prior knowledge, and relies more on analyzing the features present in the received signal to determine the modulation type [5].

In this work, our goal is to assemble and calibrate the hardware, which consists of the LimeSDR communication kits and MIMO antennas, so that signals can be transmitted and received. Then, we will use these kits to conduct machine learning classification of wireless transmissions through MATLAB programming. As shown in Figure 1, a signal would be received by the LimeSDR radio and processed by a machine learning algorithm to be classified as either 2G, 3G, or 4G based on features such as Power Spectral Density and Bandwidth.

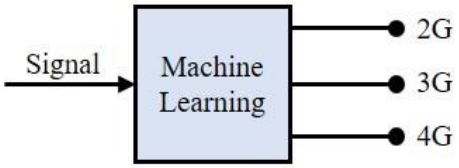

Figure 1. Using machine learning to process, analyze, and classify signals into different wireless systems (2G, 3G, or 4G).

ACKNOWLEDGEMENTS

This research is sponsored in part by the NSF REU Award number 1540040 granted to the Sensor, Signal and Information Processing (SenSIP) Devices and Algorithms REU Site.

REFERENCES

[1] A. Basu and B. Bhattacharyya, "A Study on the Integration of Machine Learning in Wireless Communication," *2018 International Conference on Communication and Signal Processing (ICCSP)*, Chennai, 2018, pp. 0974-0978.doi: 10.1109/ICCSP.2018.8524369

[2] X. Zhou, M. Sun, G. Y. Li and B. Fred Juang, "Intelligent wireless communications enabled by cognitive radio and machine learning," in *China Communications*, vol. 15, no. 12, pp. 16-48, Dec. 2018.

[3] M. Pappa, C. Ramesh and M. N. Kumar, "Performance comparison of massive MIMO and conventional MIMO using channel parameters," *2017 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET)*, Chennai, 2017, pp.1808-1812. doi: 10.1109/WiSPNET.2017.8300073

[4] Y. Zhang, J. Wang, G. Wu and Q. Tang, "Wireless Signal Classification Based on High-Order Cumulants and Machine Learning," *2018 IEEE International Conference of Safety Produce Informatization (IICSPI)*, Chongqing, China, 2018, pp. 246-250. doi: 10.1109/IICSPI.2018.8690352

[5] M. S. Mühlhaus, M. Öner, O. A. Dobre, H. U. Jäkel and F. K. Jondral, "A novel algorithm for MIMO signal classification using higher-order cumulants," *2013 IEEE Radio and Wireless Symposium*, Austin, TX, 2013, pp. 7-9. doi: 10.1109/RWS.2013.6486623