National Institute of Technology Tiruchirappalli
Electronics and Communication Engineering
Patten recognition and Computational Intelligence group

COMPSIG NITT

Second International Conference on Machine Learning, Deep Learning and Computational Intelligence for Wireless Communication

MDCWC 2023

WORKSHOP 1 INSTRUCTIONS

ONE EARTH – ONE FAMILY – ONE FUTURE

INSTRUCTIONS

Instructions from Dr. Prabhu Chandhar, Director, Chandhar Research Labs, Chennai, India

WORKSHOP 1: Deep Learning based RF Signal Classification: Hands-On"

DATE AND TIME:23rd JUNE 2023, 1.45 P.M. to 3.45 P.M.

VENUE: A13 HALL

1. Create an account on www.kaggle.com

2. Watch watch this video on how to use Kaggle platform: https://youtu.be/hBQf3fDcqaM

3. To read the basics of CNN: https://cs231n.github.io/convolutional-networks/, https://serokell.io/blog/introduction-to-convolutional-neural-networks, https://stanford.edu/~shervine/teaching/cs-230/cheatsheet-convolutional-neural-networks

4. Watch this video for some Python basics: https://youtu.be/Us9nFCOFFWU

Participation through ONLINE:
See to the WORKSHOP 1 Link in the following pdf:
http://silver.nitt.edu/~esgopi/MDCWC2023/both_workshop.pdf

Tutorial Speaker: Dr. Prabhu Chandhar, Director, Chandhar Research Labs, Chennai, India. Prabhu Chandhar received the Ph.D. degree from IIT Kharagpur, Kharagpur, India in 2015. From 2009 to 2010, he was a Senior Research Fellow at the Vodafone IIT KGP Centre of Excellence in Telecommunications, IIT Kharagpur. From 2015 to 2017, he was a Post-Doctoral Researcher at the Division of Communication Systems, Linköping University, Linköping, Sweden. Since 2018, he serves as the Director of Chandhar Research Labs, Chennai, India. His research interests are within the fields of Signal Processing and Communication Theory. https://bio.chandhar-labs.com

Abstract: Radio Frequency (RF) signal classification is a key technique of Dynamic Spectrum Access (DSA) to utilize the unused spectrum in Cognitive Radio (CR) to meet the ever-increasing traffic demands for the next generation 5G and beyond cellular networks. In recent years, the RF signal classification for CR-based applications using Deep Learning (DL) architectures has received considerable attention. This tutorial focuses on a DL-based framework with Convolution Neural Network (CNN) architecture for classifying various modulation schemes such as BPSK, QPSK and GMSK. The real-time GSM signals captured from the nearby base stations will be used to analyse the performance of the developed CNN architecture.

Tutorial Schedule (Two hours = One session):

01:45 PM - 02:00 PM: Fundamentals of Deep Learning and CNN architecture

02:00 PM - 02:30 PM: Live Demo: Dataset generation using Deep Radio® , GNU platform and Wi-Guy® 02:30 PM - 03:15 PM: Hands-on: CNN model training

03:15 PM - 03:45 PM: Hands-on: Testing and Real-Time modulation prediction

Requirements for Hands-on: The participants should possess a laptop/computer with internet connection; An account in Kaggle platform (www.kaggle.com) is required; Basic knowledge of Digital Signal Processing and Wireless Communications will be an additional advantage. Intended participants and level: This tutorial is intended for undergraduate/postgraduate students, research scholars, faculty members, industry personnel, interested in learning and developing skills to conduct Deep Learning-based project/research works in the fields of advanced wireless communication technologies.

Tutorial Outline Learning Objectives:

By the end of the tutorial, the participants shall be able,

✓ To use Kaggle platform for handling big RF datasets for DL-based wireless projects

✓ To learn Python programming tools for signal processing and DL

✓ To prepare, train, test and predict real-time wireless signals

✓ To build DL-based architectures for various wireless applications Experimental Setup: The experimental setup has been developed for dataset preparation and samples collection as shown in

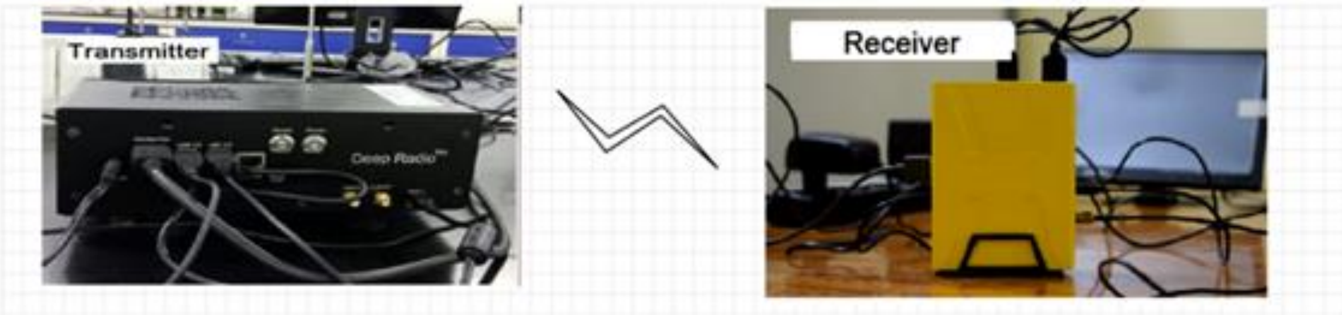

Figure 1: Experimental Setup

Figure 1. We have chosen SDRs for transmission and reception of different modulated waveforms using Deep Radio (DR) and Wi-Guy [1, 2] respectively. The transmitter and receiver SDR units are tuned at a particular carrier frequency of fc = 810 MHz.

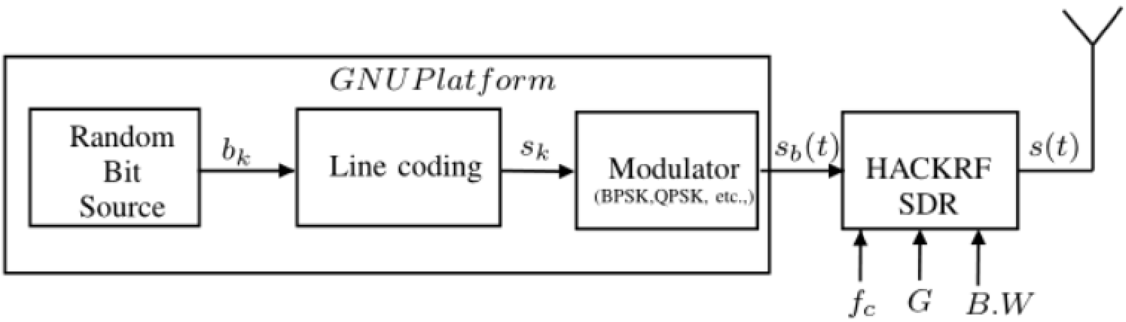

Figure 2: Deep Radio Transmitter

Deep Radio is a transceiver device comprised of SDR, telescopic antenna, and GNU companion.as shown in the Figure 2. The SDR enables fast and accurate reception of radio signals with its excellent range and capability of transmitting and receiving signals from 50 MHz to 6 GHz. The in-built open-source GNU platform can be programmed and managed as a standalone system.

GNU Platform: GNU platform is an open-source platform that provides signal processing blocks to implement SDR for various types of applications. The digital signal processing blocks are built on a graphical interface known as GNU Radio companion (GRC). The File source block in GRC reads the raw data such as text, audio, and video in binary format. The transmission parameters such as carrier frequency (fc = 810 MHz), transmitter power (Pt = 10dBm), transmitter gain (Gt = 30 dB), and bandwidth (B.W = 2.5 MHz) have been chosen in the Osmocom sink block.

Dataset preparation: Most of the related works utilize traditional datasets (RadioML2016, HisarMod2019.1) to train and validate the DL models with different levels of SNR range to classify the different types of modulation schemes. Since the artificially generated datasets do not reflect the real environment, the expected classification performance might not be achieved in practice. The performance in real-time using USRP/SDRs and FPGAs for different SNR conditions. Our approach revolves around preparing a novel dataset for modulation types by incorporating the effects of varying transmitter and receiver locations.

Model Generation/Verification: The pipeline for DL model generation consists of Data capturing using receiver, pre-processing using DL models, modulation classification using NN, and prediction (decision) is shown in Figure 3. The CNN based DL model has been generated by using the captured training dataset and evaluated by modulation classification using testing datasets, respectively. The result shows that CNN model provides better classification accuracies among the modulation schemes

Modulation prediction in RF-signal: Finally, we predict the modulation type used in real-time RF-signal transmissions (Global System for Mobile Communications (GSM)), which are captured from nearby cell towers under different scenarios.