# Machine Learning for Improved Spectrum Sensing in 4G/5G Cognitive Radio Networks

# Manual

*Instructions for running the simulations:*

The following steps should be followed to run the simulations:

1. Firstly, generate 4G/5G spectrum sensing data from MATLAB files. These include *LTE_dataGeneration_plus_energyDetection.m*, *LTE_dataGeneration_plus_matchedFilterDetection.m* and *FiveG_dataGeneration_plus_energyDetection.m.*
2. Running any of the above files generate the feature set in the form of 61 training and 61 testing files.
3. Run the *Reading_MLtest_data.m* to generate the spectrum sensing only KPI graphs.
4. Open any of the Python machine learning scripts and provide the path to the generated data.
5. Run the script to generate a text file containing the output of the machine learning phase.
6. In order to generate the final KPI graphs, run the *ML_KPI_graph_generator.m* by providing the path to the machine learning results text file.

For unsupervised learning, use the *FiveG_BandwidthParts_dataGeneration.m.* Run the *SNR_plot_kMeans.py* on the text file generated by the bandwidth part MATLAB file to see the numerologies.

*GNURadio Installation:*

<u>Prerequisite:</u> Linux OS

The instructions in this section will describe how to setup a local installation of GNURadio. The important thing to keep in mind when installing in this manner is that GNURadio will be installed to a specified directory and you may have multiple local installations, or prefixes, installed. When you run the environment setup in order to use GNURadio, you can specify which of the prefixes you want to use. This allows you make edits and add out of tree (OOT) modules to different prefixes such that you can switch between prefixes with different libraries installed every time you work with GNURadio.

Detailed Instructions: https://github.com/gnuradio/pybombs

The first thing you will need to install is the Python Build Overlay Managed Bundle System (*PyBOMBS*). If you are familiar with Ubuntu's *apt-get* functionality, this is very similar. *PyBOMBS* will help to manage your installations and make sure any dependencies are installed. It will also assist in incorporating OOT Modules.

1. Before installing *PyBOMBS*, we need to install the *pip* package manager using the apt-get package manager. Follow these steps:
    a. Make sure you apt-get is up to date:
        **$ sudo apt-get update && sudo apt-get -y upgrade**
    b. Now you should be able to install pip:
        **$ sudo apt-get install python3-pip**
    c. If you want to confirm the installation, you can run the following command to determine the version of *pip* that you have installed (as of this writing, I have pip 20.0.2 and python 3.8)
        **$ pip3 –V**
    d. (*Shouldn't be necessary now*) To upgrade to the most recent version, run
        **$ pip3 install --upgrade pip**

2. Once *pip* is installed, you can install *PyBOMBS* with
    **$ sudo pip3 install pybombs**

In this process, you will use PyBOMBS to specify what parts of GNURadio you want to install, indicate where you want it installed, and then start the installation (i.e. initialize the prefix)

1. Configure pybombs for default configuration (I get Python version 3.8.5, pyBOMBS v 2.3.4):
    **$ pybombs auto-config**

2. You will next point PyBOMBS to the "recipes" for installing the parts of GNURadio that you are interested in. As a default, you can use the following command (adds gr-recipes and gr-etcetera):
    **$ pybombs recipes add-defaults**
    • NOTE: You can see all of the recipes in your recipe list with the command:
        **$ pybombs recipes list-repos**

(*OLDER*) We use the main recipes (gr-recipes) and some additional recipes from the GNURadio folks (gr-etcetera). These recipes will be stored to ~/.pybombs/recipes
**$ pybombs recipes add gr-recipes git+https://github.com/gnuradio/gr-recipes.git**
**$ pybombs recipes add gr-etcetera git+https://github.com/gnuradio/gr-etcetera.git**

3. Create a prefix folder in your home folder.
   **$ mkdir ~/prefix**

4. Tell GNURadio where to install the prefix: (NOTE: Make sure your PC does not go to sleep during the installation. If it does, you will have to start the installation over again).
   **$ pybombs prefix init ~/prefix/default_prefix -a defprefix -R gnuradio-default**
   - The '-a' switch defines the alias when referring back to this prefix in pybombs
   - The '-R' switch specifies the prefix recipe

Once you install GNURadio locally, you will need setup the environment so that you can run the software. The setup will need to be done whenever you open a new terminal. You can easily switch between GNURadio installations (or have different installations in different terminals) by running the setup script in the folder for the prefix you want to use.

1. Setup the GNURadio prefix that you want to use by sourcing the setup_env script in the prefix. For example, setup the environment for the prefix defined above with:
   **$ source ~/prefix/default_prefix/setup_env.sh**

2. To confirm that the environment is setup, you can test by running GNURadio Companion and making sure that GRC opens:
   **$ gnuradio-companion**

3. To automatically source whenever a new terminal is opened, open the file /etc/bash.bashrc (need to open with sudo to edit) and add the source command from step 1. You should now be able to start GNURadio companion as soon as you open a new terminal without having to setup the environment.

***HackRF One Datasheet:***

For detailed information of the HackRF One SDR, visit the following website:

https://github.com/mossmann/hackrf/wiki/HackRF-One