Environmental (libraries) dependence:

1. Signal transmitting algorithm (transmitter.py)

LoRa

socket

time

2. Signal processing algorithm (receiver.py)

numpy

matplotlib

rtlsdr

scipy

cmath

time

3. Convolution neural network (CNN.py)

numpy

tensorflow

keras

random

matplotlib.pyplot

scipy.signal

4. GUI Application (GUI.py; GUI_CNN.py; GUI_SDR; GUI_Wait)

PyQt5

partial

5. TensorFlow Lite (converter.py)

tensorflow

keras

6. Label Inference (inference.py)

numpy

tensorflow

Test steps:

1. Device connection

Connect a LoPy4 device to the computer and connect the RTL-SDR to the Raspberry Pi. The Raspberry Pi can be powered through a power adapter or USB interface.

2. Transmit LoRa signals

Run the signal transmitting algorithm (transmitter.py) in PC to transmit LoRa signals. The configuration parameters of LoRa modulation are determined in this script.

```
7    # Please pick the region that matches where you are using the device:
8    # Asia = LoRa.AS923
9    # Australia = LoRa.AU915
10   # Europe = LoRa.EU868
11   # United States = LoRa.US915
12   # more params can also be given, like frequency, tx power and spreading factor
13   lora = LoRa(mode=LoRa.LORA, region=LoRa.EU868,frequency=868000000,bandwidth=LoRa.BW_125KHZ,
14
15   # create a raw LoRa socket
16   s = socket.socket(socket.AF_LORA, socket.SOCK_RAW)
17
18   t = 0
19   while t < 1000000:
20       time.sleep(0.1)
21       # send some data
22       s.setblocking(True)
23       #s.send('Hello')
24       s.send(bytes([0x00])) #1 bytes
25       print("s")
26
```

3. Run GUI application

Run the Python script (GUI.py) to start the GUI application of RFFI system. Some basic

sampling settings are inputted in the main window. According to the European standards of LoRa network, the carrier frequency should be 868 MHz. Sampling frequency should be set much greater than maximum baseband frequency to avoid aliasing. In addition, the sampling length is required to be 2 to the power of an integer to satisfy binary format. The sampling times can be randomly set. Considering the rapid response and packet loss rate, the sampling times is set to be 5.
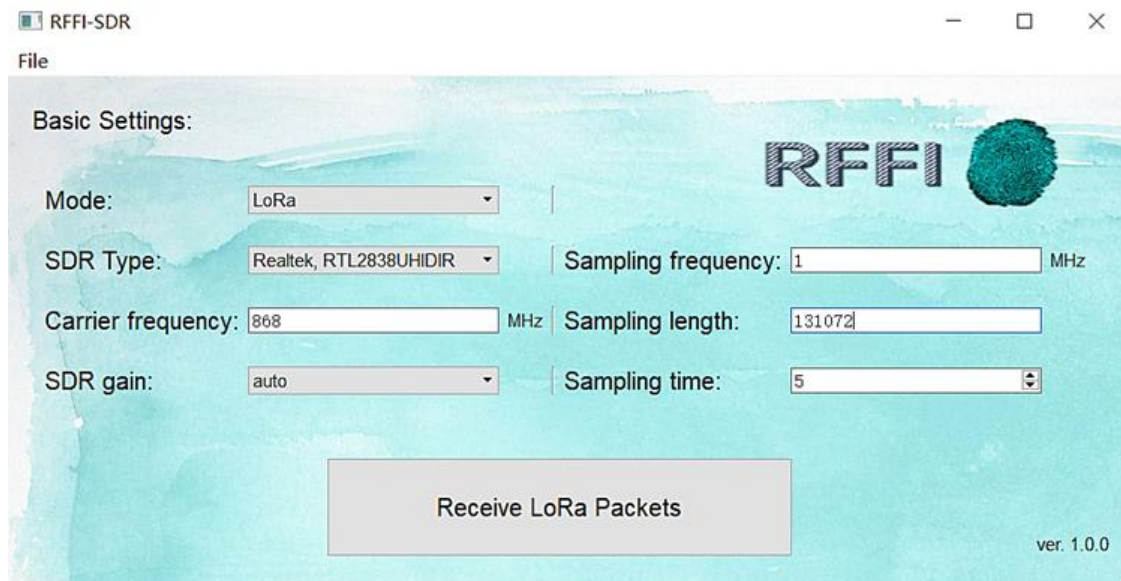

4. Receive LoRa signals

Press the "Receive LoRa Packets" button to activate the RTL-SDR for extracting the LoRa signals. Users need to wait a few seconds for SDR to collect and process all LoRa packets.

5. Infer transmitter label

Now that 3 LoRa packets have been received, users can inspect the pattern of each spectrogram by adjusting the right option bar. Press the "Search" button to open file explorer for choosing preferred CNN model. Press the "Start inference" button to predict the label of the transmitter. The result will be outputted at the bottom bar. Compare the predicted number with the true label on the LoPy4 device to evaluate the validity of RFFI system. Replace other LoPy4 device and repeat the test experiment.
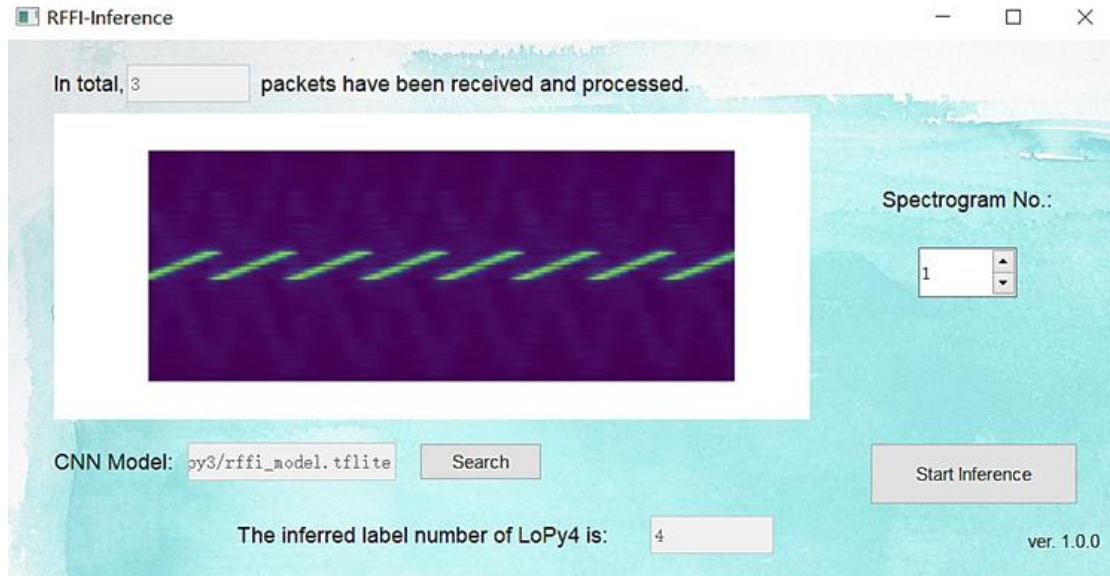
Precautions:

1. Make sure that the RTL-SDR is always the same during the signal receiving process of five transmitters.
2. Bugs have been fixed so that no deathful errors can occur.