alg_OMP_WND

August 22, 2023

[ ]:
```
import matplotlib.pyplot as plt
# Improve the quality of figures
plt.rcParams['figure.dpi'] = 300
# Times New Roman font
plt.rcParams["font.family"] = "Times New Roman"
import numpy as np
import networkx as nx
```

[ ]:
```
N_RF = 500
SNR = 5 # dB
```

Read Generated Channel Data

[ ]:
```
# read data from \generate_channel_data\generate_channel_data.mat
import scipy.io as sio
generate_channel_data = sio.loadmat('./data/generate_channel_data.mat')
cluster_para = generate_channel_data['meta_data']['cluster_para']
# xi = generate_channel_data['meta_data']['xi']
f_c = generate_channel_data['meta_data']['f_c']
N_x = int(generate_channel_data['meta_data']['N_x'])
N_y = int(generate_channel_data['meta_data']['N_y'])
lambda_c = generate_channel_data['meta_data']['lambda_c']
delta = generate_channel_data['meta_data']['delta']
N = int(generate_channel_data['meta_data']['N'])
L_x = generate_channel_data['meta_data']['L_x']
L_y = generate_channel_data['meta_data']['L_y']

H_channel = np.mat(generate_channel_data['channel']['H_channel'][0][0])
vec_H_a = np.mat(generate_channel_data['channel']['vec_H_a'][0][0])
variance = np.mat(generate_channel_data['channel']['variance'][0][0])
Psi = np.mat(generate_channel_data['channel']['Psi'][0][0])
```

[ ]:
```
xi = []
l_x_abs_max = int(L_x / lambda_c)
l_y_abs_max = int(L_y / lambda_c)
print("l_x_abs_max = ", l_x_abs_max)
print("l_y_abs_max = ", l_y_abs_max)

# for start with -l_x_abs_max to l_x_abs_max
```

```
for l_x in range(-l_x_abs_max, l_x_abs_max + 1):
    # for start with -l_y_abs_max to l_y_abs_max
    for l_y in range(-l_y_abs_max, l_y_abs_max + 1):
        k_x = 2 * np.pi * l_x / L_x
        k_y = 2 * np.pi * l_y / L_y
        if k_x ** 2 + k_y ** 2 < (2 * np.pi / lambda_c) ** 2:
            xi.append((l_x, l_y))
```

```
l_x_abs_max =  32
l_y_abs_max =  32
```

Visualize Channel

[ ]:
```
# visualize the channel
def visualize_wavenumber_domain_channel(vec_H_a):
    mat_H_a = np.mat(np.zeros((2*l_x_abs_max+1, 2*l_y_abs_max+1),␣
 ↪dtype=complex))
    # all set to np.nan in mat_H_a
    mat_H_a[:,:] = np.nan
    for l, l_pair in enumerate(xi):
        l_x = l_pair[0]
        l_y = l_pair[1]
        mat_H_a[l_x + l_x_abs_max, l_y + l_y_abs_max] = vec_H_a[l]

    # plt.figure(figsize=(10, 10))
    plt.imshow(np.abs(mat_H_a), extent=[-l_x_abs_max, l_x_abs_max,␣
 ↪-l_y_abs_max, l_y_abs_max], cmap='hot')
    plt.colorbar()
    plt.title('Instantaneous channel in WD')

def visualize_wavenumber_variance(variance):
    # plt.figure(figsize=(8, 6))
    plt.imshow(variance, cmap='jet', extent=[-l_x_abs_max, l_x_abs_max,␣
 ↪-l_y_abs_max, l_y_abs_max])
    plt.colorbar()
    plt.title('Variance of the channel')

def DFT_power_spectrum(H_channel):
    # DFT power spectrum of the channel
    DFT_power = np.abs(np.fft.fft2(np.reshape(H_channel, (N_x, N_y))))

    # element shift according to the DFT power spectrum
    DFT_power = np.fft.fftshift(DFT_power)

    # normalize the DFT power spectrum
    DFT_power = DFT_power / np.max(DFT_power)

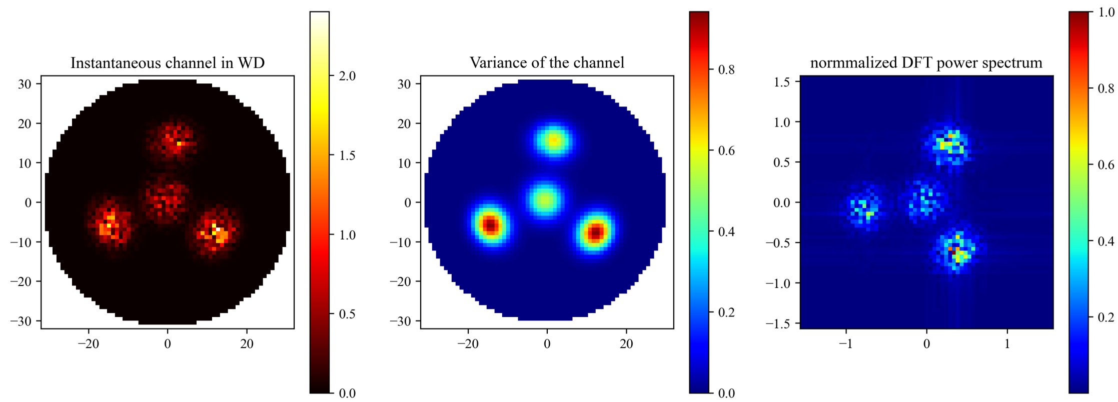
    # visualize the DFT power spectrum
```

```
    # plt.figure(figsize=(10, 10))
    plt.imshow(DFT_power, cmap='jet', extent=[-np.pi/2, np.pi/2, -np.pi/2, np.pi/2])
    plt.colorbar()
    plt.title('normmalized DFT power spectrum')

plt.figure(figsize=(14, 5))
# sub out of 3 in one row
plt.subplot(131)
visualize_wavenumber_domain_channel(vec_H_a)

plt.subplot(132)
visualize_wavenumber_variance(variance)

plt.subplot(133)
DFT_power_spectrum(H_channel)
```



Observation Model

$$\mathbf{y} = \mathbf{C}\,\mathbf{h}_a + \mathbf{n}$$

[ ]:
```
# Measurement matrxi for compressed sensing, {N}_{RF} \times N
measurement_matrix = np.random.randn(N_RF, N) * 1 / np.sqrt(N)

y = np.dot(
    measurement_matrix,
    np.dot(
        Psi, vec_H_a
    )
)
Phi = np.dot(measurement_matrix, Psi)
```

Self-made OMP alg

[ ]:
```
from tool_box.OMP import OMP
# add noise
noise = np.random.randn(*y.shape) + 1j * np.random.randn(*y.shape)
noise = noise / np.linalg.norm(noise) * np.linalg.norm(y) / 10 ** (SNR / 20)
y = y + noise

myOMP = OMP(
    A = np.array(Phi),
    y = np.array(y),
    vec_H_a = vec_H_a,
    sparseness = 0.1,
    norm_err_threshold = 1e-1)
vec_H_a_recovered, vec_H_a_nonzero_idx, vec_H_a_err = myOMP.run()
```

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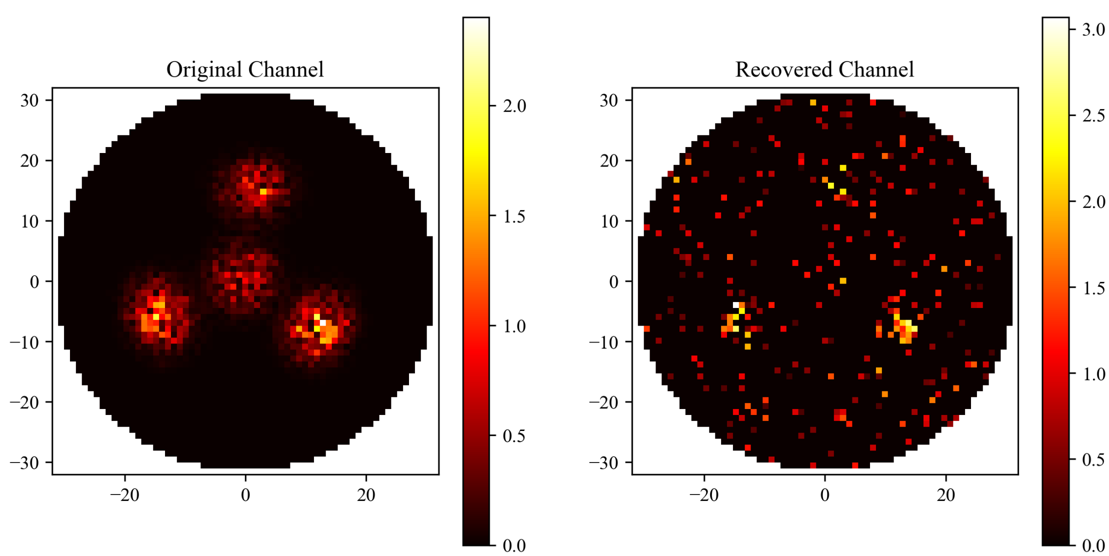
84%|      | 269/320 [00:15<00:02, 17.71it/s]
```

[ ]:
```
plt.figure(figsize=(10, 5))
# sub 1
plt.subplot(1, 2, 1)
visualize_wavenumber_domain_channel(vec_H_a)
# title
plt.title("Original Channel")

# sub 2
plt.subplot(1, 2, 2)
visualize_wavenumber_domain_channel(vec_H_a_recovered)
# title
plt.title("Recovered Channel")
```

[ ]:
```
Text(0.5, 1.0, 'Recovered Channel')
```



[ ]:

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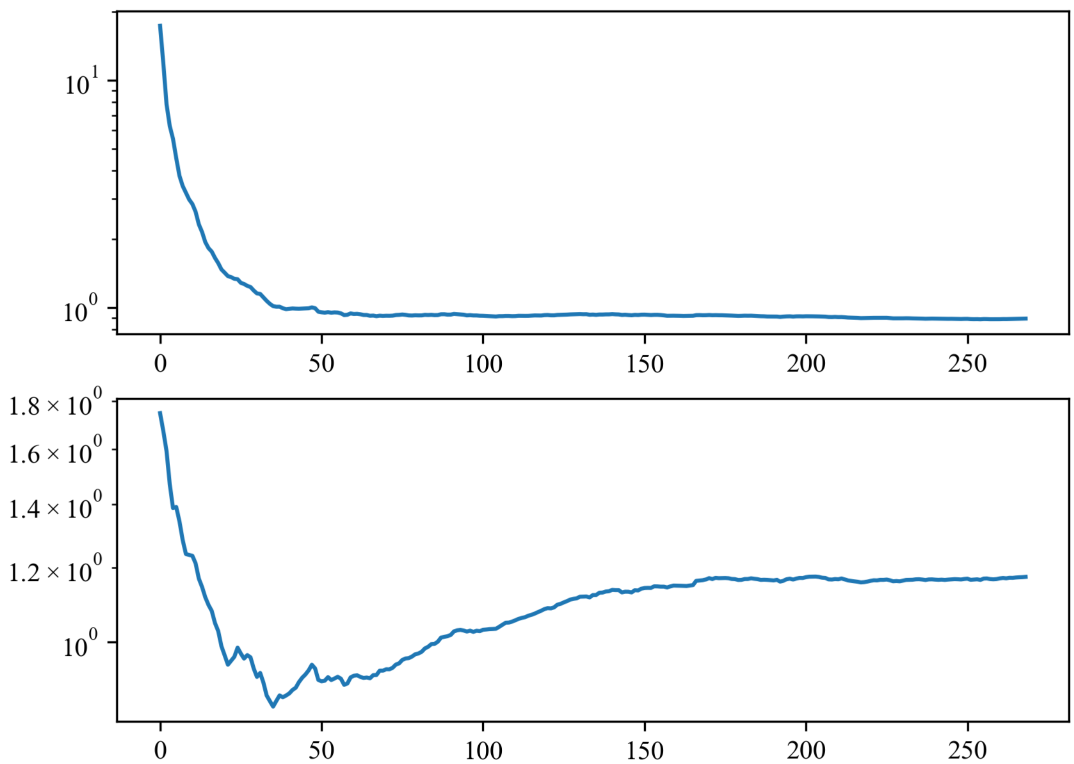
[ ]:

```
NMSE_list_v2 = myOMP.NMSE_list_v2
NMSE_list = myOMP.NMSE_list
plt.figure()
plt.subplot(211)
plt.plot(NMSE_list)
plt.yscale('log')

plt.subplot(212)
plt.plot(NMSE_list_v2)
plt.yscale('log')
# set log scale
```



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