Tp5 Dimitris

Non-blind watermark detection

Exercise 1

Read the image cameraman.tif in. It will serve as host image x. For given hypothesis:

$$H0 : v = x + z$$
$$H1 : v = x + w + z$$

where x is the host image, v is the marked image, w is the watermark and z is additive white Gaussian noise, i.e. $Z \sim N(0, \sigma^2_{noise} I)$

```
import matplotlib.image as mpimg; import matplotlib.pyplot as plt; import num

url = "https://github.com/partizanos/multimedia_security/raw/master/multimedi
response = requests.get(url)
im = Image.open(BytesIO(response.content))
X  = np.array(im)
N1, N2 = X.shape
N = int(N1*N2)
```

Hypothesis and watermark definition as on TP4

```
def imageShape(img):
  N1, N2 = X.shape
  assert X.shape == (256, 256)
  return int(N1*N2)


def watermark(gamma, img, theta):
  assert type (gamma) ==int
  N1, N2 = img.shape
  size = imageShape(img)
  assert type (size) ==int
  indices=[]

  #   Generate a matrix w' of size x with uniform distributed values {-1, 1}.
  #   The magnitude of these two values governs the watermark strength.
  w_prime = np.random.uniform(-gamma,gamma,size)
  w_prime = w_prime.reshape((N1, N2))

  #   Randomly sample from matrix w' with a given density θN = 0.5
  for i in range(int(size * theta )):
    indices.append((np.random.randint(N1), np.random.randint(N2)))

  w = np.zeros((N1,N2))
  for tup in indices:
    w[tup] = w_prime[tup]
  return w
```

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```
se, gamma, theta):
  # V = X + Z
  N1, N2 = X.shape
  Z = np.random.normal(0, sigma_noise, imageShape(X)).reshape((N1, N2))
  V_H0 = X + Z
  w = watermark(gamma, X, theta)
  V_H1 = V_H0 + w
  return V_H0, V_H1, w
```

```
38
39 def rho_non_blind(v, w, X, N ):
40   w_non_blind = v - X
41   return  np.sum(w.reshape((N))*w_non_blind.reshape((N))) / (N)
42
```

For hypothesis H_1 and ρ^{H_1} the watermark w is generated J times with a fixed strength γ = ±1 2 and a fixed density θ_N = 0.1. The noise realization z is again fixed with $\sigma_{noise} = 50$.

Fill out Table 1 with all results. Note that obviously only the noise and not the watermark has influence on hypothesis H 0 , so the relevant cells have been grayed out.

Determine rho mu and sigma parameter for H_0 and H_1

```
1 # sigmas =[50, 100];
2 # densities = [0.1, 0.3];
3 # gammas = [1, 5];
4
5 # sigma_noise = 50
6 # theta = 0.1
7 # gamma = 1
8
9
10 def experiment(X, sigma_noise, gamma, theta, J ):
11   rho_h0_list = []
12   rho_h1_list = []
13
14   for j in range(J):
15     vh0, vh1, w = get_Hypothesis(X, sigma_noise, gamma, theta)
16     rho_h0_list.append(rho_non_blind(vh0, w, X, N ))
17     rho_h1_list.append(rho_non_blind(vh1, w, X, N ))
18
19   rho_h0_list = np.array(rho_h0_list)
20   rho_h1_list = np.array(rho_h1_list)
21
22   mu_h0 = np.sum(rho_h0_list)/J
23   mu_h1 = np.sum(rho_h1_list)/J
24
25   sigma_h0 = (np.sum(rho_h0_list - mu_h0)**2) / J
26   sigma_h1 = (np.sum(rho_h1_list - mu_h1)**2) / J
27
28   print("sigma noise: ", sigma_noise)
29   print("theta: ", theta)
30   print("gamma: ", gamma)
31   print("### mu|h0: ",mu_h0, ", : mu|h1 ", mu_h1, " sigma_h0: ", sigma_h0, "s
32   return mu_h0, mu_h1,  sigma_h0,  sigma_h1
```

```
1 sigma_noise, gamma, theta = 50, 5, 0.3
2 vh0, vh1, w = get_Hypothesis(X, sigma_noise, gamma, theta)
3
4 fig, ax = plt.subplots(
5         ncols=2,
6         sharex=True,
7         sharey=True,
8         figsize=(18, 18)
9 )
10
```

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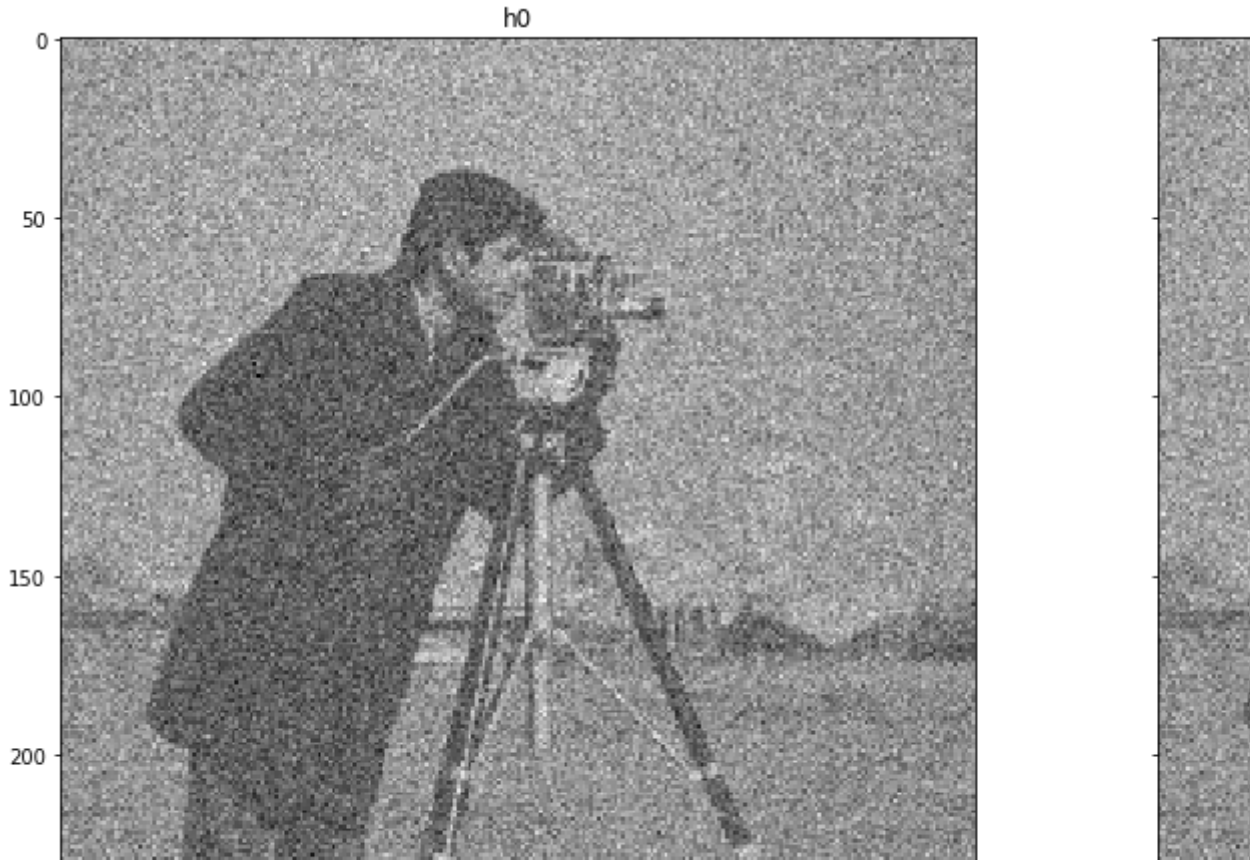
```
Text(0.5, 1.0, 'h1')
```



Calculate and display the Receiver Operating Characteristic (ROC) curve for the binary threshold test following the above mentioned experiment set up. The detection threshold is denoted with $T_{\rho\_non-blind}$.

```
from scipy.stats import norm
sigma_noise, gamma, theta = 100, 5, 0.3
J = 100

[mu_H0, mu_H1, var_H0, var_H1] =  experiment(X, sigma_noise, gamma, theta, J
threshold = np.linspace(mu_H0-var_H0,mu_H1+var_H1,12);
PFA=[]
PMISS=[]
for i in range(len(threshold)):
    PFA.append(1 - norm.cdf(threshold[i], mu_H0, var_H0))
    PMISS.append(norm.cdf(threshold[i], mu_H1, var_H1))

plt.plot(PFA); plt.title("PFA");  plt.show();
plt.plot(PMISS);  plt.title("PMISS"); plt.show();
plt.plot(PFA,PMISS);  plt.title("ROC"); plt.show();
```

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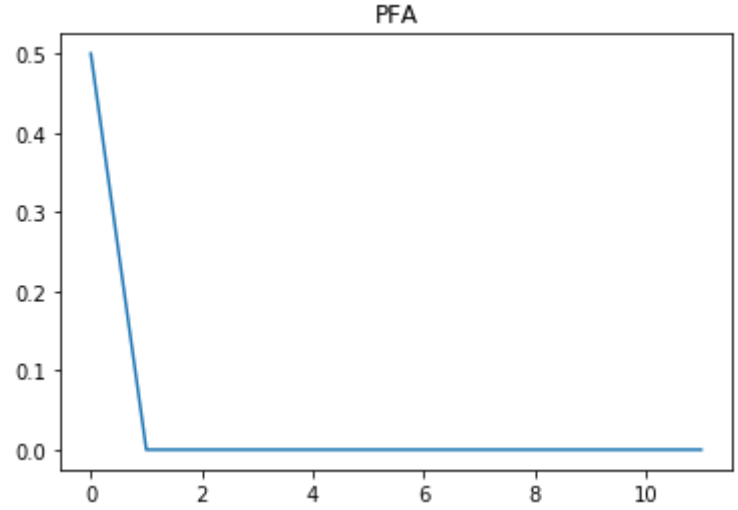
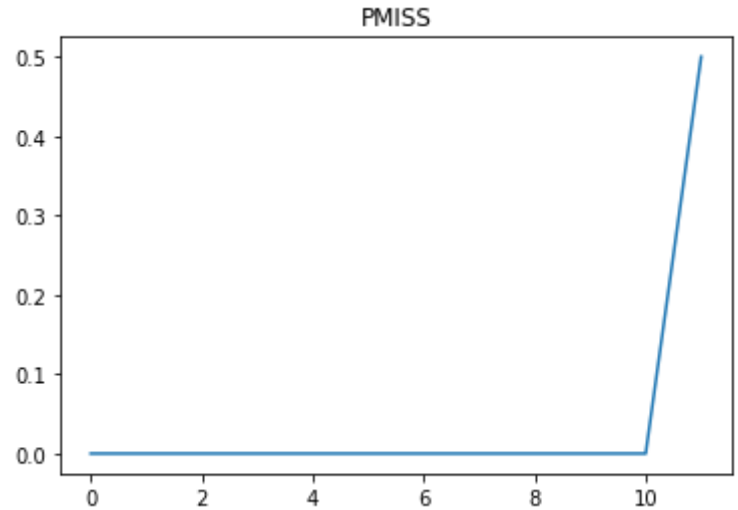
```
sigma noise:  100
theta:  0.3
gamma:  5
### mu|h0:  -0.02548606678414836 , : mu|h1  2.1349660244777806  sigma_h0:
```






```
1
2 sigmas =[50, 100];
3 densities = [0.1, 0.3];
4 gammas = [1, 5];
5 for sigma in sigmas:
6   for theta in densities:
7     for gamma in gammas:
8       print("Running experiment with parameters: ", sigma, theta, gamma)
9       mu_h0, mu_h1,  sigma_h0,  sigma_h1 = experiment(X, sigma, gamma, theta,
10
```

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```
Running experiment with parameters:  50 0.1 1
sigma noise:  50
theta:  0.1
gamma:  1
### mu|h0:  -0.0006048147958920192 , : mu|h1  0.0311205748837363  sigma_h0
Running experiment with parameters:  50 0.1 5
sigma noise:  50
theta:  0.1
gamma:  5
### mu|h0:  0.013060887013537947 , : mu|h1  0.8069949968862831  sigma_h0:
Running experiment with parameters:  50 0.3 1
sigma noise:  50
theta:  0.3
gamma:  1
### mu|h0:  0.0023710990282543114 , : mu|h1  0.0887153086698195  sigma_h0:
Running experiment with parameters:  50 0.3 5
sigma noise:  50
theta:  0.3
gamma:  5
### mu|h0:  0.007344250534054234 , : mu|h1  2.1668780809461334  sigma_h0:
Running experiment with parameters:  100 0.1 1
sigma noise:  100
theta:  0.1
gamma:  1
### mu|h0:  0.006335131955985907 , : mu|h1  0.03805583051667384  sigma_h0:
Running experiment with parameters:  100 0.1 5
sigma noise:  100
theta:  0.1
gamma:  5
### mu|h0:  0.023847004455454877 , : mu|h1  0.8154375831875413  sigma_h0:
Running experiment with parameters:  100 0.3 1
sigma noise:  100
```

What can you conclude about non-blind watermark detection given the strength of the watermark and the noise variance?

Answer

- For higher values of theta watermark mu is significantly higher.
- For sigma 100 the standarad deviation was 2 orders of magnitude higher tha for sigma 50.

Double-click (or enter) to edit

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