# Лабораторная работа №4

***Сокрытие данных в частотной области неподвижных изображений на основе кодирования разности абсолютных значений коэффициентов дискретно-косинусного преобразования***

*по курсу: "Стеганография"*

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In [1]:

```
%matplotlib inline
import re
import copy
import codecs
import numpy as np
import matplotlib.pyplot as plt

from PIL import Image
from math import cos, pi, sqrt
from scipy import fftpack
from functools import lru_cache
from pprint import pprint
```

In [2]:

```
np.set_printoptions(formatter={'float_kind':lambda x: "%.2f" % x})
```

In [3]:

```
IMG_TEMP = 'images/img{}.bmp'
STEG_IMG_TEMP = 'images/stego{}.bmp'
TEXT_FILE = 'text.txt'
MARKER = '0111111111111110'
EOL = '$$'
```

In [4]:

```
def dct(img):
    return fftpack.dct(fftpack.dct(img.T, norm='ortho').T, norm='ortho')

def idct(coefficients):
    return fftpack.idct(fftpack.idct(coefficients.T, norm='ortho').T, norm=
```

In [5]:

```
def np_2_image(array):
    try:
        return Image.fromarray(array)
    except:
        return None
```

In [6]:

```
def image_2_np(image):
    try:
        return np.array(image)
    except:
        return None
```

In [7]:

```
def open_image(filename):
    return Image.open(filename)
```

In [8]:

```
def read_text(filename):
    with codecs.open(filename, encoding='utf-8', mode='r') as f:
        return f.read().strip()
```

In [9]:

```
def str_2_bin(*args):
    return ''.join(bin(ord(x))[2:].zfill(8) for x in ''.join(args))
```

In [10]:

```
def bin_2_str(binary, length=8):
    bin_l = [binary[i:i+length] for i in range(0, len(binary), length)]
    return ''.join([chr(int(c, 2)) for c in bin_l])
```

In [11]:

```
def chunks(l, n, step=4):
    for i in range(0, len(l) - n + 1, step):
        yield l[i:i + n]
```

In [12]:

```
def get_reconstructed_image(raw):
    img = raw.clip(0, 255)
    img = img.astype('uint8')
    img = Image.fromarray(img)
    return img
```

In [13]:

```
def get_blocks(img_arr):
    b = []
    for r in range(0, img_arr.shape[0], 8):
        for c in range(0, img_arr.shape[1], 8):
            b.append(dct(img_arr[r:r + 8, c:c + 8]))
    return b
```

## Задание №1 - Реализация алгоритмов прямого и обратного дискретно-косинусного преобразования. Исследование эффекта частотной чувствительности зрительной системы человека

In [14]:

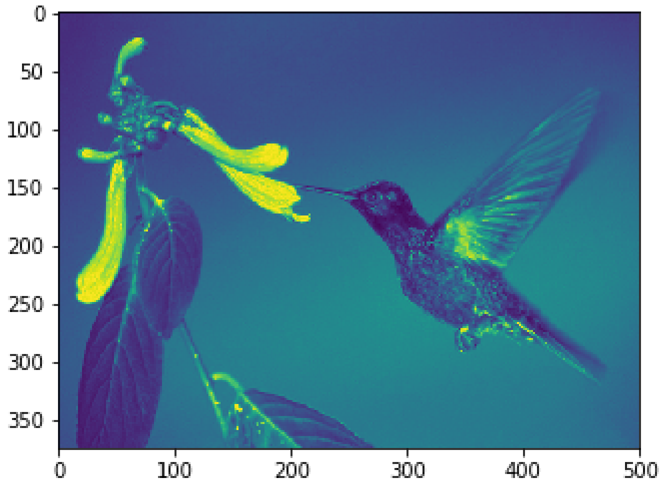
```
# @lru_cache(maxsize=128)
def C(x):
    if x == 0:
        return 1 / sqrt(2)
    elif x > 0:
        return 1
```

In [15]:

```
N = 8
P = 1

def dct2d(matrix):
    coeff = matrix.copy()
    for i in range(len(matrix)):
        for j in range(len(matrix[0])):
            coeff[i, j] = (C(i)*C(j)/sqrt(2*N))*sum([sum([matrix[x,y]\
                                                *cos((2*i+1)*pi*x/(2*N)) \
                                                *cos((2*j+1)*pi*y/(2*N)) \
                                    for y in range(N)]) for x in range(N)]
    return coeff
dct2d.__code__ = dct.__code__
def idct2d(coeff):
    matrix = coeff.copy()
    for i in range(len(coeff)):
        for j in range(len(coeff[0])):
            matrix[i, j] = 1.0 / sqrt(2.0*N)*sum([sum([C(x)*C(y)\
                                            *cos((2*i+1)*pi*x/(2*N))\
                                            *cos((2*j+1)*pi*y/(2*N))
                                for y in range(N)]) for x in range(N)])
    return matrix
idct2d.__code = idct.__code__
```

In [16]:

```
image = open_image(IMG_TEMP.format(1))
red, green, blue = image.split()
plt.imshow(red)
plt.show()
```



In [17]:

```
red_np = image_2_np(red)
```

In [18]:

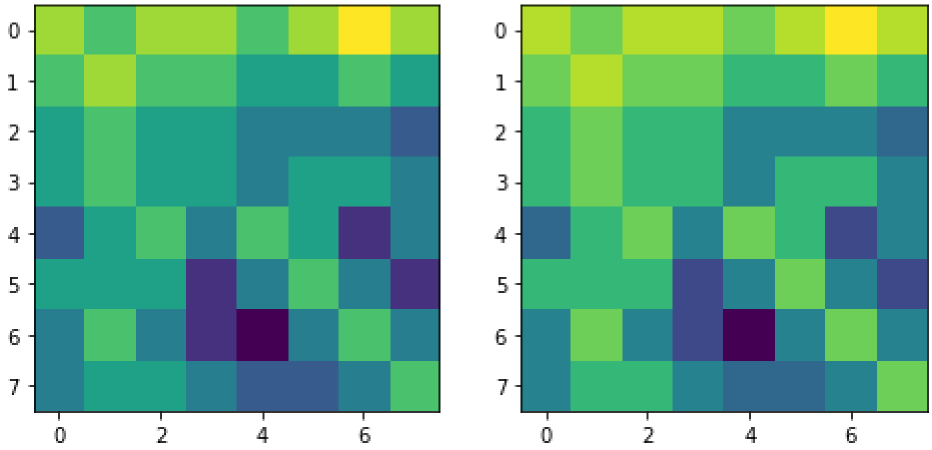
```
print('='*20 + 'DCT(1,1)'+'='*19)
print(re.sub('[ ]+', ' ', re.sub(' *[\\[\\]] *', '', np.array_str(dct2d(rec
print('='*45)
```

```
====================DCT(1,1)===================
318.63 2.18 1.18 -0.54 -3.13 -0.39 -0.08 -0.31
6.28 0.32 -1.53 0.38 1.28 1.30 -0.64 -0.20
2.99 -1.58 2.55 -1.30 0.35 1.73 -0.67 -0.11
1.66 -0.88 -0.68 1.84 -1.06 -0.30 1.39 0.87
2.12 -1.34 -1.13 -1.49 1.87 -0.54 0.87 0.12
0.15 -0.67 1.95 0.73 -1.43 1.75 -0.86 -0.63
-0.29 0.55 -0.92 0.97 0.53 0.06 0.95 0.44
-1.00 -0.17 -0.66 -1.05 0.36 -0.83 0.13 0.09
=============================================
```

In [19]:

```
a = dct(red_np[:N,:N])
b = a + 0.3*a # ~ 30%
print('='*20 + 'DCT(a)'+'='*19)
print(re.sub('[ ]+', ' ', re.sub(' *[\\[\\]] *', '', np.array_str(a))))
print('='*20 + 'DCT(b)'+'='*19)
print(re.sub('[ ]+', ' ', re.sub(' *[\\[\\]] *', '', np.array_str(b))))
print('='*45)

f,ax = plt.subplots(1,2, figsize=(8, 8))
ax[0].imshow(get_reconstructed_image(idct(a)))
ax[1].imshow(get_reconstructed_image(idct(b)))
plt.show()
```

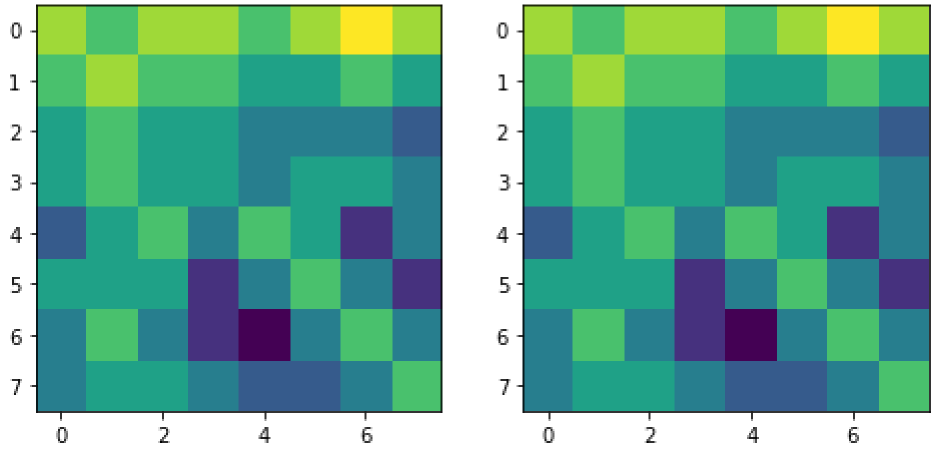
```
====================DCT(a)===================
318.63 2.18 1.18 -0.54 -3.13 -0.39 -0.08 -0.31
6.28 0.32 -1.53 0.38 1.28 1.30 -0.64 -0.20
2.99 -1.58 2.55 -1.30 0.35 1.73 -0.67 -0.11
1.66 -0.88 -0.68 1.84 -1.06 -0.30 1.39 0.87
2.12 -1.34 -1.13 -1.49 1.87 -0.54 0.87 0.12
0.15 -0.67 1.95 0.73 -1.43 1.75 -0.86 -0.63
-0.29 0.55 -0.92 0.97 0.53 0.06 0.95 0.44
-1.00 -0.17 -0.66 -1.05 0.36 -0.83 0.13 0.09
====================DCT(b)===================
414.21 2.84 1.54 -0.71 -4.06 -0.51 -0.11 -0.40
8.16 0.42 -2.00 0.50 1.66 1.69 -0.83 -0.26
3.89 -2.05 3.31 -1.70 0.46 2.25 -0.87 -0.14
2.15 -1.15 -0.88 2.40 -1.38 -0.40 1.80 1.13
2.76 -1.74 -1.46 -1.93 2.44 -0.71 1.13 0.15
0.20 -0.86 2.54 0.94 -1.86 2.27 -1.11 -0.82
-0.38 0.72 -1.20 1.26 0.69 0.08 1.24 0.57
-1.30 -0.22 -0.85 -1.36 0.47 -1.07 0.17 0.12
=============================================
```



In [20]:

```
a = dct(red_np[:N,:N])
b = a + a # ~ 100%
print('='*20 + 'DCT(a)'+'='*19)
print(re.sub('[ ]+', ' ', re.sub(' *[\\[\\]] *', '', np.array_str(a))))
print('='*20 + 'DCT(b)'+'='*19)
print(re.sub('[ ]+', ' ', re.sub(' *[\\[\\]] *', '', np.array_str(b))))
print('='*45)

f,ax = plt.subplots(1,2, figsize=(8, 8))
ax[0].imshow(get_reconstructed_image(idct(a)))
ax[1].imshow(get_reconstructed_image(idct(b)))
plt.show()
```

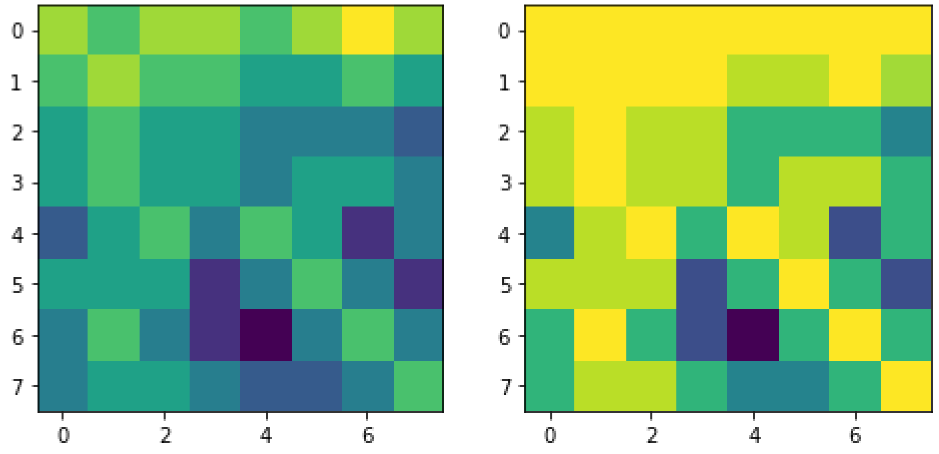
```
====================DCT(a)===================
318.63 2.18 1.18 -0.54 -3.13 -0.39 -0.08 -0.31
6.28 0.32 -1.53 0.38 1.28 1.30 -0.64 -0.20
2.99 -1.58 2.55 -1.30 0.35 1.73 -0.67 -0.11
1.66 -0.88 -0.68 1.84 -1.06 -0.30 1.39 0.87
2.12 -1.34 -1.13 -1.49 1.87 -0.54 0.87 0.12
0.15 -0.67 1.95 0.73 -1.43 1.75 -0.86 -0.63
-0.29 0.55 -0.92 0.97 0.53 0.06 0.95 0.44
-1.00 -0.17 -0.66 -1.05 0.36 -0.83 0.13 0.09
====================DCT(b)===================
637.25 4.37 2.37 -1.09 -6.25 -0.78 -0.17 -0.62
12.56 0.64 -3.07 0.76 2.56 2.60 -1.27 -0.40
5.98 -3.15 5.09 -2.61 0.71 3.46 -1.34 -0.21
3.31 -1.76 -1.36 3.69 -2.12 -0.61 2.77 1.74
4.25 -2.68 -2.25 -2.98 3.75 -1.09 1.75 0.23
0.31 -1.33 3.90 1.45 -2.87 3.50 -1.71 -1.26
-0.58 1.10 -1.84 1.94 1.06 0.12 1.91 0.88
-2.00 -0.34 -1.31 -2.10 0.72 -1.65 0.27 0.18
=============================================
```



In [21]:

```
a = dct(red_np[:N,:N])
b = a + 5.3*a # ~530%
print('='*20 + 'DCT(a)'+'='*19)
print(re.sub('[ ]+', ' ', re.sub(' *[\\[\\]] *', '', np.array_str(a))))
print('='*20 + 'DCT(b)'+'='*19)
print(re.sub('[ ]+', ' ', re.sub(' *[\\[\\]] *', '', np.array_str(b))))
print('='*45)

f,ax = plt.subplots(1,2, figsize=(8, 8))
ax[0].imshow(get_reconstructed_image(idct(a)))
ax[1].imshow(get_reconstructed_image(idct(b)))
plt.show()
```

```
====================DCT(a)===================
318.63 2.18 1.18 -0.54 -3.13 -0.39 -0.08 -0.31
6.28 0.32 -1.53 0.38 1.28 1.30 -0.64 -0.20
2.99 -1.58 2.55 -1.30 0.35 1.73 -0.67 -0.11
1.66 -0.88 -0.68 1.84 -1.06 -0.30 1.39 0.87
2.12 -1.34 -1.13 -1.49 1.87 -0.54 0.87 0.12
0.15 -0.67 1.95 0.73 -1.43 1.75 -0.86 -0.63
-0.29 0.55 -0.92 0.97 0.53 0.06 0.95 0.44
-1.00 -0.17 -0.66 -1.05 0.36 -0.83 0.13 0.09
====================DCT(b)===================
2007.34 13.76 7.45 -3.42 -19.69 -2.45 -0.53 -1.94
39.55 2.02 -9.67 2.40 8.05 8.19 -4.00 -1.25
18.84 -9.92 16.04 -8.22 2.23 10.90 -4.22 -0.67
10.44 -5.56 -4.29 11.61 -6.67 -1.92 8.73 5.50
13.39 -8.43 -7.10 -9.38 11.81 -3.42 5.50 0.73
0.96 -4.19 12.29 4.58 -9.03 11.01 -5.39 -3.98
-1.84 3.47 -5.80 6.11 3.34 0.37 6.01 2.76
-6.31 -1.06 -4.13 -6.61 2.27 -5.21 0.84 0.56
=============================================
```



## Задание №2 - Реализация алгоритмов встраивания и извлечения сообщений в частотную область изображений (метод Коха-Жао)

***Входные параметры***

In [22]:

```
N = 8
Pr = 30
message = "Стеганография"
```

In [23]:

```python
def H(h1, h2, Pr=Pr):
    if abs(h1) - abs(h2) > Pr:
        return '1'
    if abs(h1) - abs(h2) < -Pr:
        return '0'
    else:
        return -1
```

***Процедура вставки сообщения***

In [24]:

```python
def encode(image, new_image, m, Pr=Pr):
    red, green, blue = image.split()
    red = np.array(red)
    new_red = np.array(new_image.split()[0])
    x_bin = ''
    for c in m:
        x_bin += "{0:016b}".format(ord(c))
    x_bin += MARKER
    s = 0
    for r in range(0, red.shape[0], 8):
        for c in range(0, red.shape[1], 8):
            block = dct(red[r:r + 8, c:c + 8])
            first = block[1][3]
            second = block[3][1]
            if x_bin[s] == '1' and (m != H(first, second, Pr) or H(first, s
                if first > 0:
                    block[3][1] = abs(second) + Pr
                else:
                    block[3][1] = - abs(second) - Pr
            elif x_bin[s] == '0' and (m != H(first, second, Pr) or H(first,
                if second > 0:
                    block[1][3] = abs(first) + Pr
                else:
                    block[1][3] = - abs(first) - Pr
            s += 1
            new_red[r:r+8,c:c+8] = idct(block)
            if s >= len(x_bin):
                return new_red
    return new_red
```

***Процедура извлечения сообщения***

In [25]:

```python
def decode(blocks):
    ch = ''
    res = ''
    for i in range(len(blocks)):
        if abs(blocks[i].item((3, 1))) > abs(blocks[i].item((1, 3))):
            ch += '1'
        elif abs(blocks[i].item((3, 1))) <= abs(blocks[i].item((1, 3))):
            ch += '0'
        if len(ch) == 16:
            if ch == MARKER:
                return res
            try:
                res += chr(int(ch, 2))
                ch = ''
            except UnicodeEncodeError:
                return res
    return res
```

***Тестирование***

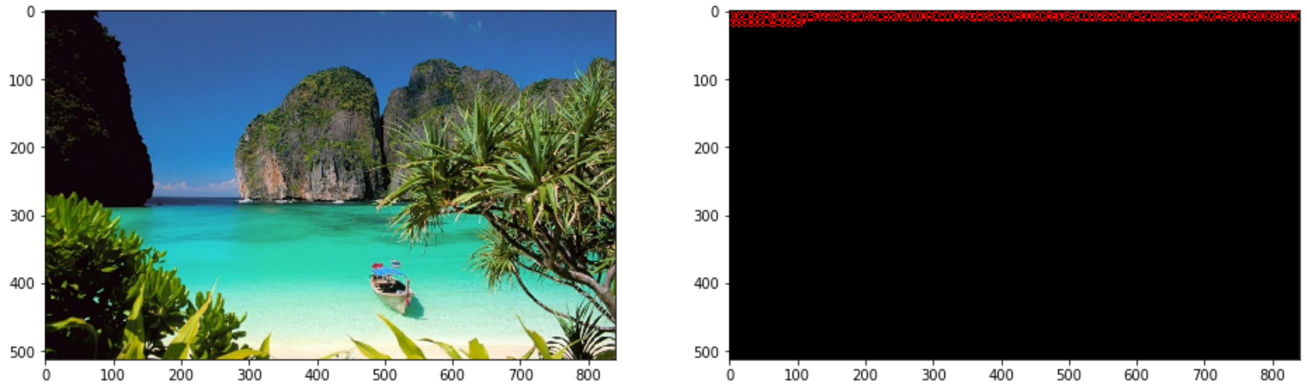
In [26]:
```
with Image.open(IMG_TEMP.format(2)) as image:
    new_image = image.copy()
    r, g, b = image.split()
    new_data = encode(image, new_image, message)
    Image.merge("RGB", (Image.fromarray(new_data), g, b)).save(STEG_IMG_TEM
print("Исходное сообщение: {}".format(message))
```

```
Исходное сообщение: Стеганография
```

In [27]:
```
with Image.open(STEG_IMG_TEMP.format(2)) as new_image:
    data = np.array(new_image.split()[0])
blocks_dct = get_blocks(data)
new_message = decode(blocks_dct)
print("Полученное сообщение: {}".format(new_message))
```

```
Полученное сообщение: Стеганография
```

In [28]:
```
with Image.open(IMG_TEMP.format(2)) as image:
    with Image.open(STEG_IMG_TEMP.format(2)) as new_image:
        f,ax = plt.subplots(1, 2, figsize=(16, 8))
        ax[0].imshow(image)
        ax[1].imshow(np_2_image(image_2_np(new_image) - image_2_np(image)))
        plt.show()
```



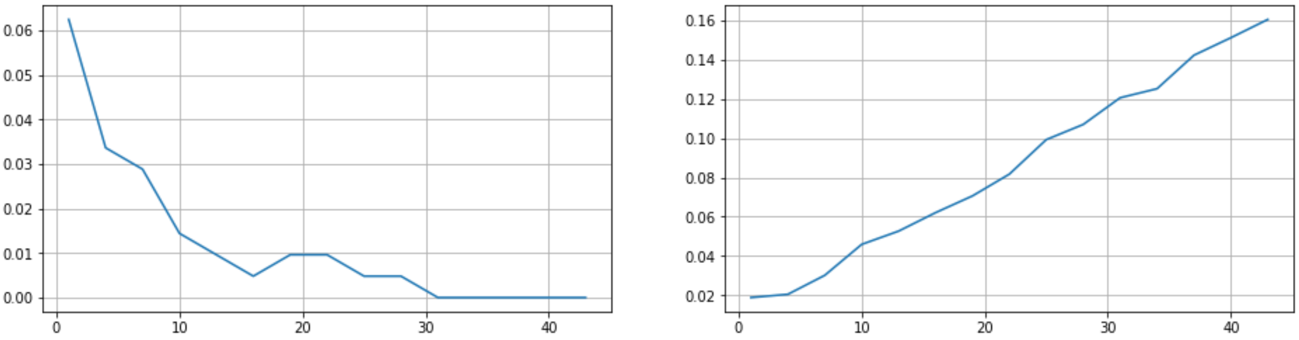
***Оценка вероятности ложного изъятия информационных данных и количественная оценка различий между изображениями до и после встраивания информационного сообщения***

In [29]:

```
X = []
X1 = []
Y = []
for i in range(1, 45, 3):
    with Image.open(IMG_TEMP.format(2)) as image:
        new_image = image.copy()
        r, g, b = image.split()
        new_data = encode(image, new_image, message, Pr=i)
        Image.merge("RGB", (Image.fromarray(new_data), g, b)).save(STEG_IM

    with Image.open(STEG_IMG_TEMP.format(2)) as new_image:
        data = np.array(new_image.split()[0])
    blocks_dct = get_blocks(data)
    new_message = decode(blocks_dct)


    m_bin = ''
    for c in message:
        m_bin = m_bin + "{0:016b}".format(ord(c))
    m_new_bin = ''
    for c in new_message:
        m_new_bin = m_new_bin + "{0:016b}".format(ord(c))

    v = 0
    for j in range(len(m_bin)):
        if m_bin[j] != m_new_bin[j]:
            v += 1
    v /= len(m_bin)
    X.append(v)
    Y.append(i)
    w = 0
    with Image.open(IMG_TEMP.format(2)) as pic:
        with Image.open(STEG_IMG_TEMP.format(2)) as new_pic:
            for t in range(pic.height):
                for p in range(pic.width):
                    w += abs(pic.getpixel((p, t))[0] - new_pic.getpixel((p,
    w /= pic.height * pic.width

    X1.append(w)
```

In [30]:

```
f,ax = plt.subplots(1, 2, figsize=(16, 4))
ax[0].plot(Y, X)
ax[0].grid(True)
ax[1].plot(Y, X1)
ax[1].grid(True)
plt.show()
```



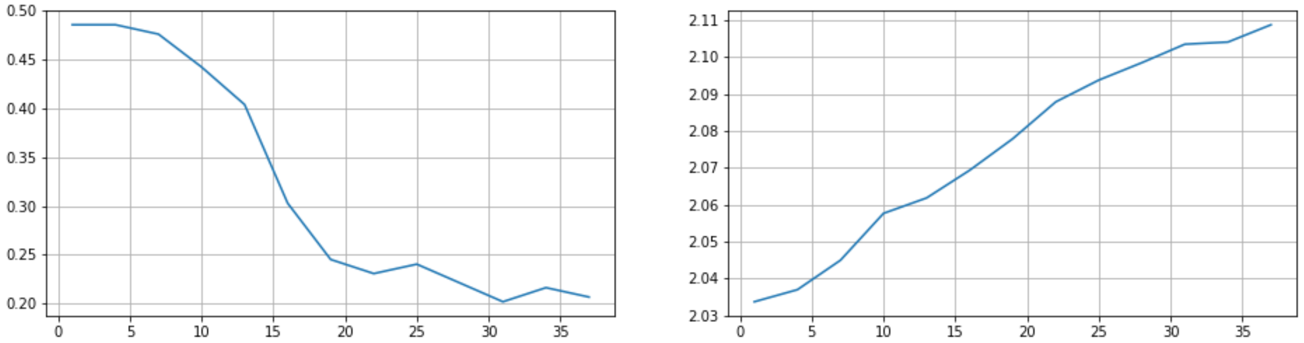
## Задание №3 - Реализация стеганоатаки на основе использования алгоритма сжатия JPEG и исследования его возможностей

In [31]:

```
X_3 = []
Y_3 = []
X1_3 = []
for i in range(1, 40, 3):
    with Image.open(IMG_TEMP.format(3)) as image:
        new_image = image.copy()
        r, g, b = image.split()
        new_data = encode(image, new_image, message, Pr=i)
        Image.merge("RGB", (Image.fromarray(new_data), g, b)).save(STEG_IM

    Image.open(STEG_IMG_TEMP.format(3)).save("images/new_image.jpg")

    with Image.open("images/new_image.jpg") as new_image:
        data = np.array(new_image.split()[0])
    blocks_dct = get_blocks(data)
    new_message = decode(blocks_dct)

    m_bin = ''
    for c in message:
        m_bin = m_bin + "{0:016b}".format(ord(c))
    m_new_bin = ''
    for c in new_message:
        m_new_bin = m_new_bin + "{0:016b}".format(ord(c))

    v = 0
    for j in range(len(m_bin)):
        if m_bin[j] != m_new_bin[j]:
            v += 1
    v /= len(m_bin)
    X_3.append(v)
    Y_3.append(i)

    w = 0
    with Image.open(IMG_TEMP.format(3)) as pic:
        with Image.open("images/new_image.jpg") as new_pic:
            for t in range(pic.height):
                for p in range(pic.width):
                    w += abs(pic.getpixel((p, t))[0] - new_pic.getpixel((p,
    w /= pic.height * pic.width
    X1_3.append(w)
```

In [32]:

```
f,ax = plt.subplots(1, 2, figsize=(16, 4))
ax[0].plot(Y_3, X_3)
ax[0].grid(True)
ax[1].plot(Y_3, X1_3)
ax[1].grid(True)
plt.show()
```



## Задача №4 - Реализация усовершенствованных алгоритмов встраивания и извлечения сообщений в частотную область изображений (метод Бенгама-Мемон-Эо-Юнга)

In [33]:

```
MARKER = '01111110'
```

In [34]:

```
def encode_mod(image, new_image, m, Pr=Pr):
    red, green, blue = image.split()
    red = np.array(red)
    new_red = np.array(new_image.split()[0])
    x_bin = ''
    for c in m:
        x_bin += "{0:08b}".format(ord(c))
    x_bin += MARKER
    s = 0
    for r in range(0, red.shape[0], 8):
        for c in range(0, red.shape[1], 8):
            block = dct(red[r:r + 8, c:c + 8])
            if x_bin[s] == '1':
                if block[3][1] > 0:
                    block[3][1] = abs(block[1][3]) + Pr
                elif block[3][1] <= 0:
                    block[3][1] = -abs(block[1][3]) - Pr
                if block[3][2] > 0:
                    block[3][2] = abs(block[1][3]) + Pr
                elif block[3][2] <=0:
                    block[3][2] = -abs(block[1][3]) - Pr
            else:
                if block[1][3] > 0:
                    block[1][3] = abs(block[3][1]) + Pr
                elif block[1][3] <= 0:
                    block[1][3] = -abs(block[3][1]) - Pr
                if block[2][3] > 0:
                    block[2][3] = abs(block[3][1]) + Pr
                elif block[2][3] <=0:
                    block[2][3] = -abs(block[3][1]) - Pr
            s += 1
            new_red[r:r+8,c:c+8] = idct(block)
            if s >= len(x_bin):
                return new_red
    return new_red
```

In [35]:

```
def decode_mod(blocks):
    ch = ''
    res = ''
    for i in range(len(blocks)):
        if abs(blocks[i].item((3, 1))) > abs(blocks[i].item((1, 3))) and \
        abs(blocks[i].item((3, 2))) > abs(blocks[i].item((1, 3))):
            ch += '1'
        elif abs(blocks[i].item((3, 1))) <= abs(blocks[i].item((1, 3))) and
        abs(blocks[i].item((3, 2))) <= abs(blocks[i].item((1, 3))):
            ch += '0'
        if len(ch) == 8:
            if ch == MARKER:
                return res
            try:
                res += chr(int(ch, 2))
                ch = ''
            except UnicodeEncodeError as ue:
                print(ue)
                return res
    return res
```

***Тестирование***

In [36]:

```
message = 'TEST'
```

In [37]:

```
with Image.open(IMG_TEMP.format(4)) as image:
    new_image = image.copy()
    r, g, b = image.split()
    new_data = encode_mod(image, new_image, message, 35)
    Image.merge("RGB", (Image.fromarray(new_data), g, b)).save(STEG_IMG_TEM
print("Исходное сообщение: {}".format(message))
```

```
Исходное сообщение: TEST
```

In [38]:

```
with Image.open(STEG_IMG_TEMP.format(4)) as new_image:
    data = np.array(new_image.split()[0])
blocks_dct = get_blocks(data)
new_message = decode_mod(blocks_dct)
print("Полученное сообщение: {}".format(new_message))
```

```
Полученное сообщение: TEST
```

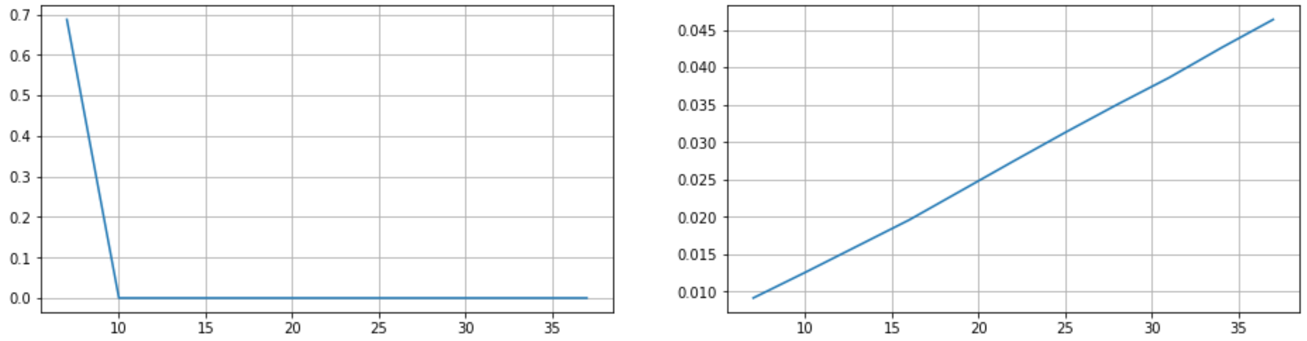
***Оценка вероятности ложного изъятия информационных данных и количественная оценка различий между изображениями до и после встраивания информационного сообщения***

In [39]:

```
X_4 = []
X1_4 = []
Y_4 = []
for i in range(7, 40, 3):
    with Image.open(IMG_TEMP.format(4)) as image:
        new_image = image.copy()
        r, g, b = image.split()
        new_data = encode_mod(image, new_image, message, Pr=i)
        Image.merge("RGB", (Image.fromarray(new_data), g, b)).save(STEG_IMG

    with Image.open(STEG_IMG_TEMP.format(4)) as new_image:
        data = np.array(new_image.split()[0])
    blocks_dct = get_blocks(data)
    new_message = decode_mod(blocks_dct)


    m_bin = ''
    for c in message:
        m_bin = m_bin + "{0:08b}".format(ord(c))
    m_new_bin = ''
    for c in new_message:
        m_new_bin = m_new_bin + "{0:08b}".format(ord(c))

    v = 0
    for j in range(len(m_bin)):
        if m_bin[j] != m_new_bin[j]:
            v += 1
    v /= len(m_bin)
    X_4.append(v)
    Y_4.append(i)
    w = 0
    with Image.open(IMG_TEMP.format(4)) as pic:
        with Image.open(STEG_IMG_TEMP.format(4)) as new_pic:
            for t in range(pic.height):
                for p in range(pic.width):
                    w += abs(pic.getpixel((p, t))[0] - new_pic.getpixel((p,
    w /= pic.height * pic.width

    X1_4.append(w)
```

In [40]:

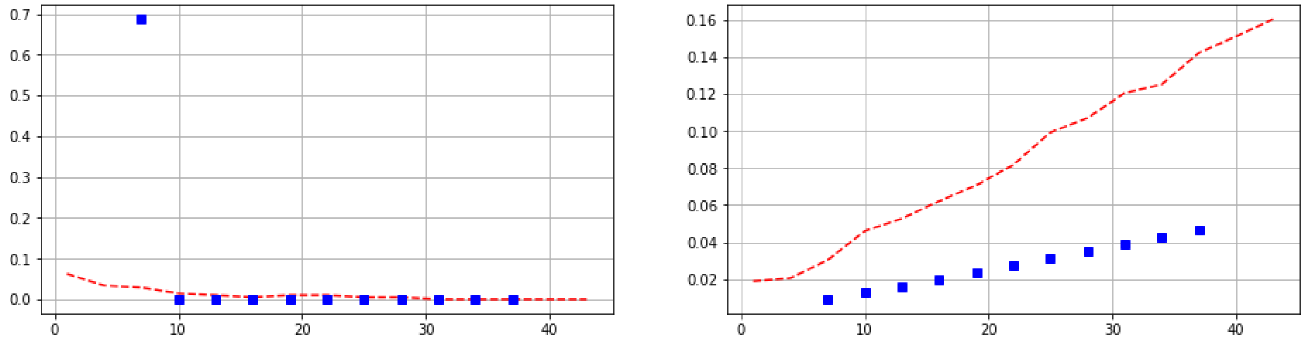
```
f,ax = plt.subplots(1, 2, figsize=(16, 4))
ax[0].plot(Y_4, X_4)
ax[0].grid(True)
ax[1].plot(Y_4, X1_4)
ax[1].grid(True)
plt.show()
```



### *Построение эмпирических зависимостей вероятности ложного извлечения информационных данных и средней величины внесенных искажений в контейнер-изображение от величины порога «Pr»*

In [41]:

```
f,ax = plt.subplots(1, 2, figsize=(16, 4))
ax[0].plot(Y, X, 'r--', Y_4, X_4, 'bs')
ax[0].grid(True)
ax[1].plot(Y, X1, 'r--', Y_4, X1_4, 'bs')
ax[1].grid(True)
plt.show()
```


0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
40
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0
10
20
30
40