Task 3: Extract image hidden inside an image

My picture number is #6 and two rows are 3 and 4 for the Steganography assignment

Image # 06

Row #3, #4

208 224 240	125 174 79	221 238 255	208 224 240
208 224 240	125 174 79	125 174 79	208 224 240
112 160 64	192 80 32	144 192 80	112 160 64
176 192 224	205 94 47	189 206 239	176 192 224

ROUND 1

First pixel: row 3, column 1, RGB values: (112, 160, 47). We are going to extract the hidden colour values using conversion to binary.

RED: 250 is 01110000 in binary

The four least significant digits are 0000.

We use these are the leading digits of the hidden colour value: 00000000

We then convert 00000000 to decimal, which gives us 0. And so, the hidden value for red is 0.

GREEN: 160 is 10100000 in binary

The least significant digits are 0000.

The hidden colour value is 00000000

Convert 00000000 to decimal 0. The hidden value for GREEN is 0.

BLUE: 64 is 00100000 in binary

The least significant digits are 0000

The hidden colour value is 00000000

Convert 00000000 to decimal: 0. The hidden value for BLUE is 0.

The hidden colour value is RGB 0,0,0.

ROUND 2

Second pixel: row 4, column 2, RGB values: (205, 94, 47). We are going to extract the hidden colour values using conversion to hexadecimal.

RED: 205 is CD in hexadecimal

The least significant digit is D.

We use these are the leading digits of the hidden colour value: D0

We then convert D0 to decimal, which gives us 208. And so, the hidden value for red is 208.

GREEN: 94 is 5E in hexadecimal

The least significant digits are E.

The hidden colour value is E0

Convert E0 to decimal 224. The hidden value for GREEN is 224.

BLUE: 47 is 2F in hexadecimal

The least significant digits are F

The hidden colour value is F0

Convert F0 to decimal: 240. The hidden value for BLUE is 240.

The hidden colour value is RGB 208,224,240.

ROUND 3

We can use bitwise arithmetic to retrieve the hidden image from the input image, **without** requiring us to convert to binary / hexadecimal. The method described in the explanation section below.

Third pixel: row 3, column 3, RGB values: (144, 192, 80). We are going to extract the hidden colour values using bitwise operations.

RED: The decimal equivalent for the 4 least significant bits of the pixel 144 & 15 = 0, which is also the decimal equivalent of the 4 most significant bits of the hidden pixel (where $(15)_{10} = (0F)_{16}$).

Hence, the hidden value for red is 0*16 = 0 (which can be computed with 0 << 4, left shift).

GREEN: The decimal equivalent for the 4 least significant bits of the pixel 192 & 15 = 0, which is also the decimal equivalent of the 4 most significant bits of the hidden pixel.

Hence, the hidden value for GREEN is 0*16 = 0.

BLUE: The decimal equivalent for the 4 least significant bits of the pixel 80 & 15 = 0, which is also the decimal equivalent of the 4 most significant bits of the hidden pixel.

Hence, the hidden value for BLUE is 0*16 = 0.

The hidden colour value is RGB 0,0,0.

Fourth pixel: row 4, column 3, RGB values: (189, 206, 239). Again, we are going to extract the hidden colour values using bitwise operations.

RED: The decimal equivalent for the 4 least significant bits of the pixel 189 & 15 = 13, which is also the decimal equivalent of the 4 most significant bits of the hidden pixel (where $(15)_{10} = (0F)_{16}$).

Hence, the hidden value for red is 13*16 = 208 (which can be computed with 13 << 4, left shift).

GREEN: The decimal equivalent for the 4 least significant bits of the pixel 206 & 15 = 14, which is also the decimal equivalent of the 4 most significant bits of the hidden pixel.

Hence, the hidden value for GREEN is 14 << 4 = 14*16 = 224.

BLUE: The decimal equivalent for the 4 least significant bits of the pixel 239 & 15 = 15, which is also the decimal equivalent of the 4 most significant bits of the hidden pixel.

Hence, the hidden value for BLUE is 15 << 4 = 15*16 = 240.

The hidden colour value is RGB 208,224,240.

EXPLANATION OF METHOD USED IN ROUND 3

For each pixel **p**, expressed as 3-tuple $(\mathbf{p_R, p_G, p_B})$ corresponding to 3 colour channels red, green, blue (where each p_R, p_G, p_B value is represented as **decimal**, 8 bit unsigned integer value), do the following to retrieve the hidden pixel **q** from it, again , expressed as 3-tuple $(\mathbf{q_R, q_G, q_B})$:

1. Retrieve the 4 least significant bits from **p** using **logical AND** with (decimal value) 15 (since $\mathbf{(15)_{10} = (0F)_{16}}$ or **0x0F**), to extract the 4 most significant bits of the hidden image **q**, for each colour channel:

$(p_R, p_G, p_B) = p$
$q_R = p_R$ & 15
$q_G = p_G$ & 15
$q_B = p_B$ & 15

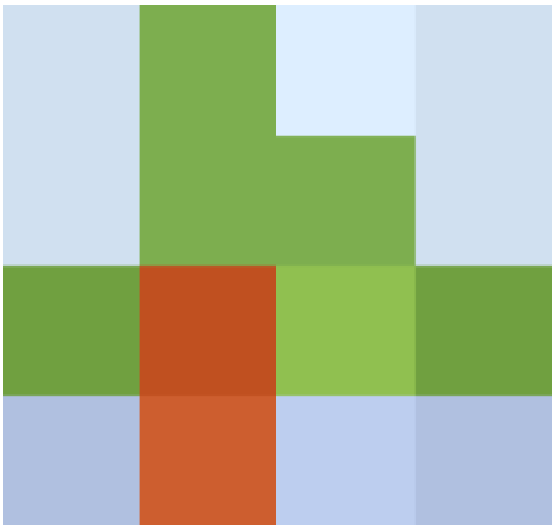
2. Left shift by 4 bits (**bitwise arithmetic**) for each colour channel of the hidden image and combine them as 3-tuple to obtain hidden image **q**:
$q_R = q_R << 4$
$q_G = q_G << 4$
$q_B = q_B << 4$
$q = (q_R, q_G, q_B)$

The python code implementing the above is shown below, it accepts the cover image and returns the hidden image.

```python
def extract_hidden_visualize(im):
    h, w, _ = im.shape
    m = np.zeros((h, w, 3), dtype=np.uint8)
    for i in range(h):
        for j in range(w):
            for c in range(3):
                m[i,j,c] = (im[i,j,c] & 0x0F) << 4
    return m
```

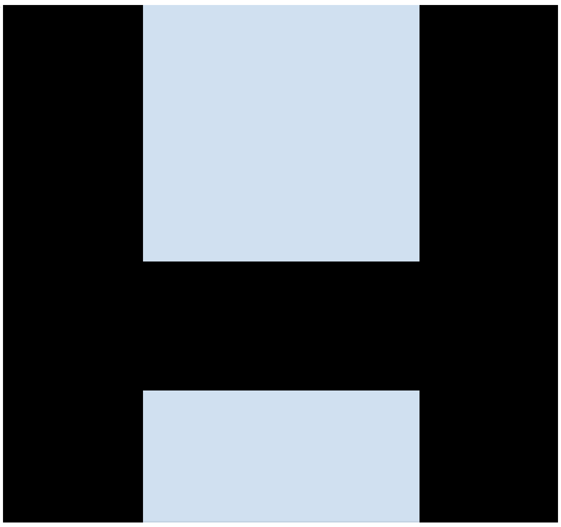
RESULTS FROM MY IMAGE

My initial image and colour values:



208 224 240	125 174 79	221 238 255	208 224 240
208 224 240	125 174 79	125 174 79	208 224 240
112 160 64	192 80 32	144 192 80	112 160 64
176 192 224	205 94 47	189 206 239	176 192 224

Hidden image colours values and image:

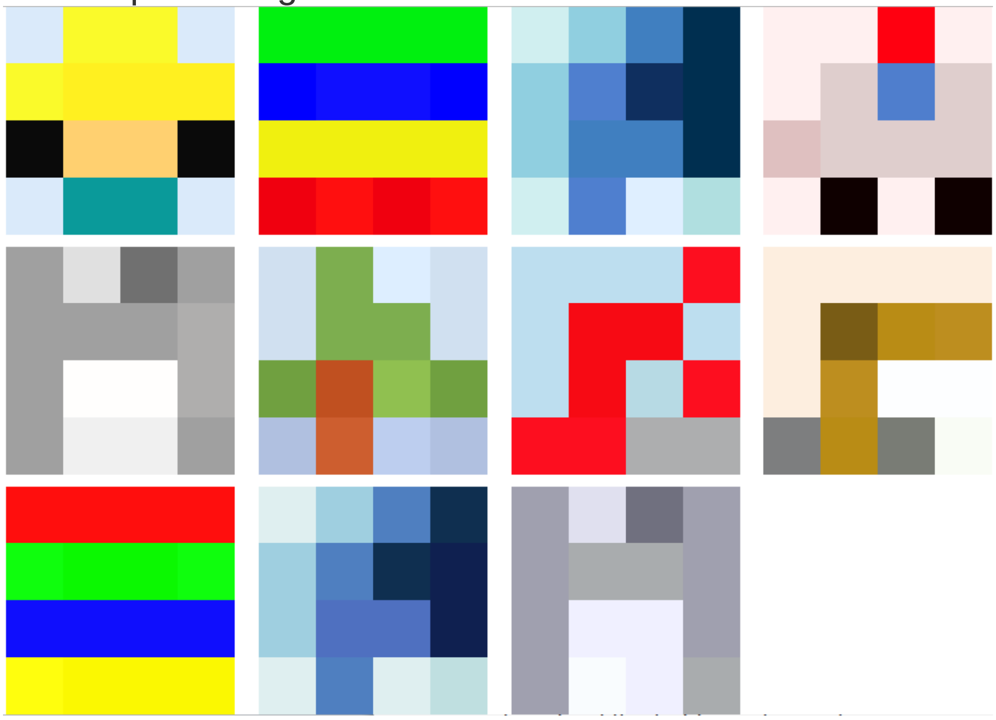


0 0 0	208 224 220	208 224 220	0 0 0
0 0 0	208 224 220	208 224 220	0 0 0
0 0 0	0 0 0	0 0 0	0 0 0
0 0 0	208 224 220	208 224 220	0 0 0

Corresponding Letter: H

RESULTS FROM ALL IMAGES

The 11 pixel images are shown below:



The 11 decoded hidden images are shown below:

Letters in order:

G,R,A,C,E,H,O,P,P,E,R