**Lab 12: Steganography**

**Background**

Steganography is the practice of hiding information in some data or message. Contrasted with encryption, the goal of stenography is to produce a final message, which to the casual observer is unaltered, but actually contains a secret message.

In this lab you will create two MATLAB scripts: one to embed a message in a grayscale image and another to extract the message using the original image and the coded image.

A grayscale image is a 2-d array with pixels that vary from 0 (black) to 255 (white). Values in between are shades of grey becoming darker as the pixel value decreases.

**A. Converting a Message to Binary**

In Lab 10 (Secret Codes), you used a Caesar cipher to encrypt a message by shifting the letters of the alphabet to new letters. In this lab, you will be converting the ASCII values associated with the letters, numbers, and symbols to 8 bit binary numbers (i.e., each character will be converted to a string of 8 ones and zeros).

As an example, consider the capital letter, H. The ASCII value for ‘H’ is 72. The corresponding 8-bit binary code (‘01001000’) is shown in the table below.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **8-bit Binary Code for ‘H’** | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| **Bit Values (Powers of 2)** | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |

Each bit represents a power of 2, starting on the right with 2^0 and ending on the left with 2^7. If we add up the bit values corresponding to the bits with 1s, we have: 64 + 8 = 72 (the ASCII code for letter ‘H’).

Another example, consider the small letter, i. The ASCII value for ‘i’ is 105. The corresponding 8-bit binary code (‘01101001’) is shown in the table below.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **8-bit Binary Code for ‘i’** | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 |
| **Bit Values (Powers of 2)** | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |

Adding up the bit values corresponding to the bits with 1s, we have: 64 + 32 + 8 + 1 = 105 (the ASCII code for letter ‘i’).

Clearly the smallest number you can make with this 8-bit format is 0. **What is the largest number you can store with this 8-bit format? ANS: 255**

The ***dec2bin*** function in MATLAB can be used to convert a message to a string of bits. At command prompt, type each of the following commands. Paste in the results.

>> message = ‘Hi!’

**Results:**

**message =**

**Hi!**

>> message = double(message)

**Results:**

message =

72 105 33

>> bin\_message = dec2bin(message,8)

**Results:**

bin\_message =

01001000

01101001

00100001

You can see that bin\_message is currently a 2-d array with each character in the original message forming a row in the array. It would be more convenient to have a 1-d array of all the bits for our encoding scheme. Type each of the following commands into MATLAB. Paste in the results and an explanation of what each command does.

>> bin\_message = bin\_message’

**Results:**

**bin\_message =**

**000**

**110**

**011**

**000**

**110**

**000**

**000**

**011**

**What did this command do?**

**The command flipped the rows and the columns and made the columns in row form. Bin\_message started as a 3x8 array. Now it is an 8x3 array.**

>> bin\_message = bin\_message(:)

**Results:**

**bin\_message =**

**0**

**1**

**0**

**0**

**1**

**0**

**0**

**0**

**0**

**1**

**1**

**0**

**1**

**0**

**0**

**1**

**0**

**0**

**1**

**0**

**0**

**0**

**0**

**1**

**What did this command do?**

It turned the first array into a single column. The column starts with [1,1] of the first array and continues to go from right to left as the array moves down in rows until the array gets to [3, 8].

>> bin\_message = bin\_message’

**Results:**

**bin\_message =**

**010010000110100100100001**

**What did this command do?**

It moved the previous single column array into a single row array.

**B. Importing Images, Displaying Images and Understanding the uint8 Format.**

Download the cat.png image file from Blackboard under Lab 12 and save it in your Current MATLAB folder.

Type the following commands into MATLAB:

>> Pic = imread('Cat','png');

>> imshow(Pic)

Now you know how to import an image into MATLAB and how to display the image.

Look in your workspace window at the variable Pic and answer the following questions:

**What is the size of Pic? ANS: 168 x 300**

**What is the datatype for the values in Pic? ANS: Array**

**uint8** stands for unsigned 8 bit integer. In Part A, you learned that unsigned 8-bit integers can range from 0 to 255. Try the following commands.

>> a = uint8(255)

>> a + 1

**Results:**

**a =**

**255**

**ans =**

**255**

>> b = uint8(0)

>> b - 5

**Results:**

b =

0

ans =

0

***Important Note:*** Since uint8 values can only range from 0 to 255, any computations you do with these values will be forced to stay in this range – a very important thing to remember!

**C. Hiding a message in an Image**

Here is how the coding scheme will work. Suppose the user inputs the message: ‘Hi’. You will convert the message to a binary string using the commands from part A. The following table illustrates how the message will be encoded into CodedPic.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| bin\_message | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 |
| Pic | 254 | 255 | 75 | 75 | 75 | 73 | 73 | 74 | 74 | 72 | 72 | 72 | 72 | 73 | 73 | 73 |
| CodedPic | 254 | 254 | 75 | 75 | 76 | 73 | 73 | 74 | 74 | 73 | 73 | 72 | 73 | 73 | 73 | 74 |

* If a bit in bin\_message is 0, then the corresponding pixel value for CodedPic is exactly the same value as the pixel value in Pic.
* If the bit in bin\_message is a 1, then the corresponding pixel value for CodedPic is Pic + 1 unless the original pixel value is 255 in which case we subtract 1. (Why? Go back and look at the math exercise at the end of Part B).

Write a script file to do the following:

1. Clean up your workspace by making the first command: clear; close all;
2. Prompt the user for a message and convert it to 1-d binary string.
3. Import the cat image and save it under some variable such as Pic.
4. Create a new variable for the coded image (CodedPic) and set it equal to Pic. Do not overwrite the values in Pic. In order to decode the message (Part D), you will need both the original image and the coded image.
5. Determine the size of CodedPic using the **size** command (don’t hardcode the number of rows and columns).
6. Write a conditional statement that checks to see if the message is too long to fit in the image. If it is too long, use the ***error*** function to tell the user that the message is too long and terminate the script.
7. Create a nested loop with the ***outer loop going through the rows*** of CodedPic and the ***inner loop going through the cols*** of CodedPic. Within your loops, modify the pixels of CodedPic using the coding scheme described above.

* You will need an additional variable to track your way through bin\_message starting at entry 1, incrementing by 1 within the loops, and ending when you run out of bits (***break***). This is not an additional loop!
* bin\_message is a string of 1s and 0s. So, to determine if an entry is a 1, **DO NOT USE: if bin\_message(n) ==1**. **Use the strcmp function:** **strcmp(bin\_message(n),’1’).**

1. After the loops, use the imshow command to display the original image and the coded image. Remember, the command ***figure*** will open a new figure window so you won’t lose the first image. Add titles to both indicating which is the original and which is the coded image.
2. Finally, use the imwrite command to save CodedPic as a png file:

imwrite(CodedPic,'CodedCat.png');

Test your code using the following message:

The more that you read, the more things you will know. The more that you learn, the more places you'll go. Dr. Seuss

If you get errors, debug away. Otherwise, if you get two images, run the following two commands in the command window and verify with your TA that your encoding scheme is indeed working properly:

>> Pic(1:4,1:8)

**Results:**

5 1 1 1 1 0 0 1

0 0 0 0 0 0 0 0

0 0 0 0 0 0 0 0

0 0 0 0 0 0 0 0

>> CodedPic(1:4,1:8)

**Results:**

5 2 1 2 1 1 0 1

0 1 1 1 0 1 1 1

0 1 1 0 0 0 0 1

0 0 1 1 0 1 1 0

**Once you have verified that all is correct, paste you two images in the space below.**

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**Can you see any differences between the two images?**

**Any visible obvious changes cannot be seen from the two images.**

**Paste Script Here:**

clear;close all;

message = input('What message would you like to hide? ','s');

message = double(message);

bin\_message = dec2bin(message,8);

bin\_message = bin\_message';

bin\_message = bin\_message(:);

bin\_message = bin\_message';

[R,C] = size(bin\_message);

Pic = imread('Cat','png');

imshow(Pic);

CodePic = Pic;

[row,col] = size(CodePic);

if size(message) > size(CodePic)

error('Your message is too big')

end

i = 1;

for k = 1:row

for q = 1:col

if strcmp(bin\_message(i),'1') && (Pic(k,q) == 255)

CodePic(k,q) = Pic(k,q) - 1;

elseif strcmp(bin\_message(i),'1') && (CodePic(k,q) < 255 )

CodePic(k,q) = Pic(k,q) + 1;

elseif strcmp(bin\_message(i),'0')

CodePic(k,q) = Pic(k,q);

end

i = i + 1;

if i > R \* C

break

end

end

if i > R \* C

break

end

end

figure; imshow(Pic)

title('Original');

figure; imshow(CodePic)

title('Hidden');

imwrite(CodePic,'CodedCat.png');

**D. Extracting the Message**

To recover the message, we need both the coded image and the original image because the message is actually the absolute value of the difference between the two images.

Write a script file to do the following:

1. Clean up your workspace by making the first command: clear; close all;
2. Use the ***imread*** command to import Cat.png and CodedCat.png
3. Convert both image arrays, Pic and CodedPic, to doubles.
4. Create a new array, Difference = abs(Pic – CodedPic). This array is now filled with 1s and 0s corresponding to the original binary message.
5. Create a nested loop with the **outer loop going through the rows** of Difference and the **inner loop going through the columns** of Difference. Within the loops, extract the original binary message. Example: if Difference(row,col) is a 1, then bin\_message(n) = ‘1’.
6. Now that you have the original binary message string, you will need to grab 8 bits at a time and convert each set of 8 bits back to the original message character:

message(1) = char(bin2dec(bin\_message(1:8)))

message(2) = char(bin2dec(bin\_message(9:16)))

Obviously, you want to do this with a for loop!

Run your script and see if you successfully extract the original Dr. Seuss quote using the Cat.png and CodedCat.png images.

**Paste Script Here:**

clear; close all;clc;

Pic = imread('Cat','png');

CodedPic = imread('CodedCat','png');

Pic = double(Pic);

CodedPic = double(CodedPic);

Difference = abs(Pic - CodedPic);

[row, col]= size(Difference);

s1 = size(Difference);

Bin\_message = '';

Final\_message = '';

i = 1;

for r = 1:row

for c = 1:col

if Difference(r,c)==1

Bin\_message(i)= '1';

else

Bin\_message(i) = '0';

end

i = i+1;

end

end

first = 1;

second = 8;

for mess = 1:length(Bin\_message)

if second > length(Bin\_message)

break

else

Final\_message(mess) = char(bin2dec(Bin\_message(first:second)));

first = first + 8;

second = second + 8;

end

end

disp(Final\_message)

**E. Extracting Messages from Intercepted Images**

Due to your success with decrypting the Caesar Cipher a few weeks ago, you have been promoted by the Engineering Models Acquisition of Information League (EMAIL), which is a super-secret organization tasked with intercepting and decrypting messages. The company has intercepted several e-mails which appear to have duplicate grayscale images as attachments and is suspicious about this activity.

1. Download the Message\_Interceptor\_v2.p file from Blackboard and save it in your current folder. This is p-code so you really don’t want to open it because it will just look like a bunch of gibberish.
2. Download the Lab12.mat file and save it in your current folder. The Message\_Interceptor\_v2.p program will use this data file.
3. Modify your Decoding script as follows:

* Comment out the two image read commands to read Cat.png and CodedCat.png
* Add the following imread commands:

Pic = imread('Image1','png');

CodedPic = imread('Image2’,’png’);

* If you used variable names different from Pic and CodedPic, change the commands above to reflect your variable names. Don’t change Image1 and Image2.

1. Run Message\_Interceptor\_v2 in the command window:

>> Message\_Interceptor\_v2

In your workspace, you should now see Image1.png and Image2.png. You should

also see the two images displayed in a figure.

1. Now run your modified Decoding script. Paste the figure with the two images and the extracted message in the spaces indicated below.

**Images:**

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**Extracted Message:**

**"In times of change, learners inherit the earth, while the learned find themselves beautifully equipped to deal with a world that no longer exists." Eric Hoffer**

**Questions:**

1. How many letters could you hide in a 2736 x 3648 grayscale image using the encryption scheme from this lab?

1247616 letters can be hidden inside of an image 2736 x 3648.

1. Assuming the typical English word in text is five letters long and we want the words separated by spaces, approximately how many words could you hide in a 2736 x 3648 grayscale image?

207936 words can be hidden in there with these restrictions.

1. According to Amazon’s Text Stats, the median length of a novel is 64,000 words. How many novels could you hide in a 2736 x 3648 grayscale image?

**3.429 novels could be hidden in an image this large.**

**To be turned in:** This document with results, scripts, and answers to the questions.