MAT 201 A
Project Report

Jeungah Kim
Wei-Ting Huang

Topic
Complexity of Images – Interpreted in Art and Engineering perspective

Concept
How we see the image through our eyes is different from what the computer sees!

Introduction
One of us is from MAT department, and the other is from ECE. We exchanged the past assignments by chance and found that the way we view things are quite different. Since both of us are interested in further research about complexity, in this project we plan to reduce the complexity of several artists’ paintings by sampling, and then interpret the results and the original images in two views.

Implementation Method
The following Fig 1 is the frame of this project:

```
<table>
<thead>
<tr>
<th>Interpret its complexity in art</th>
<th>Interpret its complexity in art</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original painting</td>
<td>Simplified painting</td>
</tr>
<tr>
<td>Interpret its complexity in EE</td>
<td>Interpret its complexity in EE</td>
</tr>
</tbody>
</table>
```

Project Flow

The sampling part will be implemented by MATLAB as the following Fig 2:

```
Original Image

<table>
<thead>
<tr>
<th>R</th>
<th>G</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Separate it into blocks with size $h \times h$
In each block, take mean values of the pixels and then quantize the value

Simplified Image
```

As above
As above
As above
The program can perform simplification of images in two ways. The first way is to separate each frame into blocks with different size, such as 4x4, 8x8, or 16x16. Next we will assign the mean value of each block as the new value of elements in that block. The second way is to quantize the pixel level from original 256 levels to less level number, such as 128 or 64. Using these two ways, we can reduce the memory volume used for storing an image.

To interpret the results in Electrical Engineering, the histogram and entropy will be used. Since we read the color image files in Matlab, there are three matrixes representing Red, Green, and Blue. Then we will generate the histograms for each of the three color domains. Histogram is the distribution of pixel numbers to each intensity level, from 0 to 255. Entropy is a measure of image information, stands for the amount of information which must be coded. The entropy of each color domains is calculated as the following equation:

\[ H = - \sum_{k=0}^{G-1} P(k) \log_2(P(k)) \]

G is level number
\( P(k) \) is the probability of level k

Part I. Loss of Information
(a)

Birthday (Marc Chagall)

| Jeungah Kim | Wei-Ting Huang |
The original painting conveys a sad love story, which is that her dead husband visits her on her birthday to take her to heaven.

We can guess this story by her clothing color and a couple of objects in her house such as a dish, a knife, etc.

Through these objects, you can guess this is a home, which is used by a person instead of a couple.

The modified image by MATLAB lost all this information. Since users can’t observe these objects, this painting become meaningless.

So, in my opinion, there was a big loss of information between the original and the modified version.

The original painting seems like a happy couple, if I am going to describe this painting, I will focus on the couple and their action.

It is not so colorful but has a lot of details, which infers that it is hard to compress the image without losing those details, such as the pattern on the wall.

The simplified image removes a lot of shapes and textures. Also, the entropy of the simplified image is reduced. However, it just decreases a little compared with the original painting's entropy.

(b)

Saint-Georges Majeur au repuscule
San Giorgio Maggiore at Twilight (Claude Monet)

<table>
<thead>
<tr>
<th>Jeungah Kim</th>
<th>Wei-Ting Huang</th>
</tr>
</thead>
<tbody>
<tr>
<td>This is Monet’s painting who is a father of impressionist painting.</td>
<td>When I see the original painting, I feel that it is very complex, because there is no pattern in it and its texture seems delicate.</td>
</tr>
<tr>
<td>The impressionist wants to draw…</td>
<td>The simplified image does not vary a lot from the original one, and I can tell the outline of original image from the simplified one.</td>
</tr>
<tr>
<td>- Subjects chosen for painting usually pertained to what the artist actually saw in his/her everyday life</td>
<td>- Instead of waiting for successive applications to dry, wet paint was painted onto wet paint in order to produce softer edges and better intermingling of colors.</td>
</tr>
<tr>
<td>- Paint was applied in short, thick strokes, usually in a sketch-like form. The essence of a subject was to be captured rather than all of its details.</td>
<td>- Darker shades of a color were made by mixing complementary colors. Black pigment was used only as a color in its own right.</td>
</tr>
<tr>
<td>- The essence of a subject was to be captured rather than all of its details.</td>
<td>- Even though, MATLAB reduced information, the modified version of an image didn’t lose the impressionist’s painting style.</td>
</tr>
<tr>
<td>- Darker shades of a color were made by mixing complementary colors. Black pigment was used only as a color in its own right.</td>
<td>So, in my opinion, there was very little information lost between the original and the modified version.</td>
</tr>
<tr>
<td>- Instead of waiting for successive applications to dry, wet paint was painted onto wet paint in order to produce softer edges and better intermingling of colors.</td>
<td>Now, it is much easier if we want to send the simplified image from one display device to another by simply recording the squares color.</td>
</tr>
<tr>
<td>Even though, MATLAB reduced information, the modified version of an image didn’t lose the impressionist’s painting style.</td>
<td>The entropy of the simplified image is less, which infers that the information contains in it is less than the original image. However, when we compare the entropies of the two images, surprisingly the amount of decreasing is very small.</td>
</tr>
</tbody>
</table>

![Bar chart showing human perception](chart1.png)

![Bar chart showing computer perception](chart2.png)
This is a Chinese painting. If you look at the details of this painting, there are a lot of Chinese characters which represent peoples’ names who owned this painting. Since this painting was very famous, people bought or pass down this painting, wanted to print their name on the painting for record purposes.

Because of those names, this painting is more valuable nowadays. However the simplified version of the painting lost all this information by reducing colors.

So, in my opinion, there was a big loss of information between original and modified version.

When I see the original painting, I think that the stamps and words surrounding the painting are more interesting than the painting itself. However, they are constituted with a lot of thin lines, which are much easier to be removed during simplification.

As for me, the simplified image loses the most interesting part, which is the poems, words, and stamps beside the painting. If we simplified it more, we almost lose everything.

Originally the entropy is less than other images. After simplification, the entropy becomes smaller.
Part II. Comparison of color between human and MATLAB

Sunrise(Claude Monet)

<table>
<thead>
<tr>
<th>Jeungah Kim</th>
<th>Wei-Ting Huang</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>This is another impressionist painting by Claude Monet. The impressionists want to express air and light, so they applied as little pigment mixing as possible. So when we observe their painting, we will see a lot of white color and not much of primary (red, green and blue) colors. So I expect that if we draw a data graph about the color level of red, green and blue, it should represents a very small amount of data</em>.</td>
<td><em>Comparing the histograms, we can discover that the original one has continuous distribution, while the simplified one has very discontinuous shape since the process of simplification groups the similar lever together. This phenomena is very interesting, I think human have the intention to create linking between colors</em>.</td>
</tr>
</tbody>
</table>
Appendix: Code

```matlab
aim = imread('file.jpg');  % input
aR = aim(:,:,1);
aG = aim(:,:,2);
aB = aim(:,:,3);
[h, w, e] = size(aim);
newim = zeros(h, w, e);
newR = zeros(h, w);
newG = zeros(h, w);
newB = zeros(h, w);
enew = zeros(2, 3);
block_size = [4, 8, 16, 32];
block = block_size(4);  % choose block
scale_range = [8, 16, 32, 64, 128];
scale = scale_range(3);  % choose scale
ea = zeros(1, 3);
ea(1) = entropy(aR);
ea(2) = entropy(aG);
ea(3) = entropy(aB);
o_en = (ea(1) + ea(2) + ea(3)) / 3;
figure
subplot(1, 2, 1); imshow(aim); title('Original Image');
% non-scale version
for i = 1:block:h
  for j = 1:block:w
    region = aR(i:i+block-1, j:j+block-1);
    a_value = mean2(region);
    newR(i:i+block-1, j:j+block-1) = a_value;
    region = aG(i:i+block-1, j:j+block-1);
    a_value = mean2(region);
  end
end
```
newG(i:i+block-1, j:j+block-1)=a_value;
region= aB(i:i+block-1, j:j+block-1);
a_value=mean2(region);
newB(i:i+block-1, j:j+block-1)=a_value;
end
end

%scale version
for i=1:block:h
    for j=1:block:w
        region= aR(i:i+block-1, j:j+block-1);
a_value=mean2(region);
temp=round(a_value/scale);
temp=temp*scale;
newR(i:i+block-1, j:j+block-1)=temp;
region= aG(i:i+block-1, j:j+block-1);
a_value=mean2(region);
temp=round(a_value/scale);
temp=temp*scale;
newG(i:i+block-1, j:j+block-1)=temp;
region= aB(i:i+block-1, j:j+block-1);
a_value=mean2(region);
temp=round(a_value/scale);
temp=temp*scale;
newB(i:i+block-1, j:j+block-1)=temp;
    end
end
newR=uint8(newR);
newG=uint8(newG);
newB=uint8(newB);
enew(1,1)=entropy(newR);
enew(1,2)=entropy(newG);
enew(1,3)=entropy(newB);
ne_en=(new(1,1)+new(1, 2)+new(1, 3))/3;
newim=cat(3, newR, newG, newB);
subplot(1, 2, 2); imshow(newim); title('Simplified Image');
figure
subplot(3, 2, 1); imhist(aR); title('histogram of R');
subplot(3, 2, 3); imhist(aG); title('histogram of G');
subplot(3, 2, 5); imhist(aB); title('histogram of B');
subplot(3, 2, 2); imhist(newR); title('histogram of R');
subplot(3, 2, 4); imhist(newG); title('histogram of G');
subplot(3, 2, 6); imhist(newB); title('histogram of B');