APPLICATIONS OF DCT

MAT 201 PRESENTATION

VINIT PATEL
MS-ECE

DCT (DISCRETE COSINE TRANSFORM)

\[ X_{k_1,k_2} = \sum_{n_1=0}^{N_1} \sum_{n_2=0}^{N_2} x_{n_1,n_2} \cos \left( \frac{\pi}{N_1} (n_1 + \frac{1}{2}) k_1 \right) \cos \left( \frac{\pi}{N_2} (n_2 + \frac{1}{2}) k_2 \right). \]

- Used to decompose the spatial frequency of image in terms of various cosines
- Widely used in various image compression schemes
DCT OF IMAGE

MAT PROJECT

- Use of DCT to
  - Calculate Frequency complexity of image
  - Group images with similar frequency components
- Demos of
  - Progressive JPEG
  - Frequency selective image reconstruction
FREQUENCY COMPONENTS

• Reconstruct the image using frequency components successively
• Used to transfer images over a period of time with initial quality to be low and quality improvement over time.

PROGRESSIVE JPEG
PROGRESSIVE JPEG

FREQ components used

1

FUEL ELECTRICITY

FREQUENCY COMPLEXITY

- Reconstruct image using
  - low frequency components
  - successively add the high frequency components
- Mean Difference Error (MDE) = mean of pixel wise difference of actual and reconstructed image
- Check: MDE < quality threshold ($\gamma$)
- No. of iterations required to achieve the $\gamma$ is frequency complexity
EXAMPLE TO FIND FREQUENCY COMPLEXITY

• Table of various MDE

<table>
<thead>
<tr>
<th>Iteration</th>
<th>MDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.521</td>
</tr>
<tr>
<td>2</td>
<td>3.7596</td>
</tr>
<tr>
<td>3</td>
<td>2.8679</td>
</tr>
<tr>
<td>4</td>
<td>2.0991</td>
</tr>
<tr>
<td>5</td>
<td>1.4095</td>
</tr>
<tr>
<td>6</td>
<td>0.8478</td>
</tr>
<tr>
<td>7</td>
<td>0.3609</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
</tr>
</tbody>
</table>

IMPORTANCE OF FREQUENCY COMPLEXITY

• Gives an estimate of how much frequency content an image has
• Gives an estimate of how much compression can be achieved for an image for a quality threshold
• THUMB RULE: lower frequency complexity => higher compression ratio achievable
FREQUENCY COMPLEXITY

• Which is more complex?

512 x 512  256 x 256
GROUPING OF IMAGES WITH SIMILAR FREQUENCY COMPLEXITY

- **Concept**: Group similar images, for e.g. Beach scenes, forest scenes etc based on their frequency content.
- **Approach**: Compare high frequency components
  - **Reason**: Low frequency components do not have much details

LOW FREQUENCY COMPARISON

- Low Freq components are same - but images are different, so comparison using low frequency components is not useful.
GROUPING OF IMAGES
• **Goal**: To group the following two pictures into one category.

GROUPING OF IMAGES
• Combine these two images too in one category
ALGORITHM

- Get 8x8 DCT of an images
- Compare last (63rd) AC component of the DCT of the images
- Check whether difference is below certain threshold
- YES => Group the images
- NO => Move ahead with next image

ALGORITHM LOOPHOLES

- Gives improper results for images that do not have high frequency complexity
- For these two figures of same video, the difference in freq components is large
ALGORITHM CONSTRAINTS

- Gives perfect results for images that have high frequency complexity.
- For these two figures of the same video, the difference in frequency components is very small.

WAYS TO AVOID LOOPHOLE

- Determine the block that should be considered for comparison based on the average value of the block.
- But this needs extensive testing before getting solid results.
RESULT WITH MULTIPLE IMAGES

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>-28</td>
<td>-8</td>
<td>-0.7</td>
<td>-19</td>
<td>0.2</td>
<td>-2.2</td>
<td>-1.9</td>
<td>-2.2</td>
<td>-3</td>
<td>-2.2</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>-13.9</td>
<td>0.9</td>
<td>-0.6</td>
<td>1.2</td>
<td>-3.2</td>
<td>-0.6</td>
<td>-3.3</td>
<td>-4.6</td>
<td>-0.7</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>13.1</td>
<td>21.3</td>
<td>6.9</td>
<td>-0.6</td>
<td>21.3</td>
<td>-0.8</td>
<td>-0.7</td>
<td>23.4</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-2.7</td>
<td>11.1</td>
<td>-3.1</td>
<td>-0.7</td>
<td>-3.2</td>
<td>-4.5</td>
<td>-0.8</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2.5</td>
<td>-4.5</td>
<td>0.5</td>
<td>-4.6</td>
<td>-6.9</td>
<td>-0.1</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-2</td>
<td>-3.5</td>
<td>-2</td>
<td>-2.7</td>
<td>-3.4</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4.6</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-4.6</td>
<td>-4.6</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7.5</td>
</tr>
<tr>
<td>11</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

IMAGES USED FOR THIS EXPT.

CONCLUSION

- DCT is a very important tool for media processing especially images
- DCT can be used for various applications that we discussed
- Lower frequency complexity => Higher compression achievable
- Higher frequency complexity => Better grouping possible
QUESTIONS

Questions are guaranteed in life;
Answers aren’t.

THANK YOU