COMPRESSION OF COLOUR IMAGES USING MACHINE LEARNING ALGORITHM

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ABSTRACT
The increase use of transfer of images from one device to another created a need to compress them without compromising their quality. Machine learning algorithm forms a potential method to compress an image by clustering thus leading to elimination of redundant colours. k-means algorithm is an unsupervised machine learning algorithm which clusters data and hence elected as best method for compression of colours. In this paper we propose compression of an image using k-means algorithm and variation of size of image for different values of k. Moreover comparison of k-means with JPEG and wavelet compression algorithms is performed deriving their advantages, disadvantages and compression ratio.

Keywords: machine learning, K-means, unsupervised learning, JPEG, wavelets transform.

1. INTRODUCTION: PRINCIPLE BEHIND COMPRESSION
A general characteristic of most images is that they contain redundant information as their neighbouring pixels are correlated. Two fundamental components of compression are redundancy reduction and irrelevancy elimination [1]. Redundancy reduction removes duplication from the signal source. Irrelevancy elimination is removing of signal which is not noticed by Human Visual System. Apart from these an interesting method introduced in this paper is reduction of colour based on neighbouring similarity to such an extent that its size is reduced uncompromising the quality. Compression techniques as stated in [6, 7] is also presented.

2. K MEANS ALGORITHM
K-Means [2] is an unsupervised learning algorithm. K means clustering algorithm gains its name from its method of operation. It deals with fixing k centres, one for each cluster. Here k is an input parameter. The best choice of defining centres is placing them as far as possible. Clusters are formed based on proximity of other cluster with defined centroids. The cluster’s mean is then computed and the process is repeated again [2, 10, 11, 12].

The separated cluster looks like as shown in Figure-1 is just starting phase of Clustering which is termed as 2nd iteration then progressively following it Figure-2, Figure-3, Figure-4 and then Figure-5 states that K-means has reached its extreme saturation after which there is no affect in centroids changing iterations.

Figure-1. Extreme saturation after iteration 2 at k=16.

Figure-2. Extreme saturation after iteration 3 at k=16.

Figure-3. Extreme saturation after iteration 4 at k=16.
3. ADVANTAGES OF K-MEANS FOR COLOR IMAGE COMPRESSION

K-means is least complex, fast, robust and easy to understand, relatively efficient and accurate. Result is clearer when data are separated and distinct from each other. Hence above advantages makes K-means stand out different from other algorithms.

4. ALGORITHM

Let $X = \{x_1, x_2, x_3, \ldots, x_n\}$ be the data points and $V = \{v_1, v_2, \ldots, v_c\}$ be the cluster centers.

Step-1: We randomly select ‘m’ cluster centers known as centroids.

Step-2: Calculate the distance between each data point and centroids.

Step-3: Assign the data point to the centroids whose distance from the centroid is minimum of all the centroids.

Step-4: Recalculate the new centroid using:

$$V_i = \left(\frac{1}{c_i}\right) \sum_{j=1}^{c_i} x_j$$  

where, ‘m,’ represents the number of data points in $i^{th}$ cluster.

Step-5: Recalculate the distance between each data point and new obtained centroids.

Step-6: If no data point was reassigned then stop, otherwise repeat from step-3.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>K value</th>
<th>Size (in kb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>500</td>
<td>31.3</td>
</tr>
<tr>
<td>2</td>
<td>200</td>
<td>29.2</td>
</tr>
<tr>
<td>3</td>
<td>100</td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td>50</td>
<td>20.4</td>
</tr>
<tr>
<td>5</td>
<td>18</td>
<td>11.7</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>380(bytes)</td>
</tr>
</tbody>
</table>

Figure-6 is pictorial representation of changing K value and its effects in image on which compression is applied.

5. LOSSLESS VS. LOSSY COMPRESSION

In lossless [8, 18] compression file size is changed but its quality remains unchanged. Also, the file can be decompressed to its original quality whereas Lossy compression is irreversible and hence it’s difficult to retrieve data. Lossy compression tends to achieve much higher compression as compared to lossless.

Image coder

An Image Coder contains (a) Source Encoder (b) Quantizer, and (c) Entropy Encode.

Source encoder (or Linear Transformer)

It includes Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT), and Discrete Wavelet Transform (DWT)
Quantizer

It reduces number of bits required to store transformed coefficient by reducing precision of those values. Quantization performed in each individual coefficient is termed as Scalar quantization whereas when it is performed on a group of coefficient then it is known as vector Quantization.

Entropy encoder

Entropy encoder [9] is a lossless data compression scheme. This encoder compresses the quantized values further to provide a better compression, compresses digital data by using frequently occurring patterns with less bits and rarely occurring pattern with huge amount of bits. Huffman encoder [ ] is most commonly used encoder.

6. VARIOUS COMPRESSION ALGORITHMS

A. JPEG

JPEG [14, 17] stands for joint photographic Expert group ia a lossy compression algorithm. This algorithm takes the advantage that human cannot see high frequency colours from their eyes and hence these high frequency contents are eliminated to compress the image.JPEG uses transform coding. According to observation intensity value changes in small amount in smaller area, the process starts with splitting of image into 8x8 non-overlapping pixel block and if the image cannot be divided into blocks then padding of empty pixels are done. Then colour space transformation from RGB to [YCbCr] which is Brightness, colourblueness and colour redness respectively. Discrete cosine transform of image is taken. Quantize the DCT coefficient according to psycho visually tuned quantization table. Zigzag scanning is performed to arrange low frequency coefficient at top and less frequency at bottom and thus image is efficiently compressed by run length coding or Huffman coding. Information loss occurs only at time of quantization.

B. Wavelet transform

Wavelets [3, 4, 5] are mathematical function that divide or cut up data into different frequency components and then study each components with resolution matched to its scale. Wavelets transform decomposes a signal into a set of basis functions. These basis functions are termed as wavelets Figure-7 is working components of wavelet transform.

Figure-7. Wavelet transform flowchart.

Compressed image

As seen in [13, 15] the above model is prepared and implemented for comparison in table.

Figure-8. Original image.
Figure-7 is the original image used in K-means compression and then after application of wavelet compression to this image results are noted and observed in following figures mentioned, fig 8 is with coefficient value 5 and hence least compressed as compared to other figures with less distortion whereas in fig 9 and fig 10 as we reduce coefficient value the distortion increases and hence the compression.

7. OBSERVATION

K-means is algorithm is least complex compression method and hence provide best quality image even after compression. As the K value decreases the quality also decreases and hence compression increases. Therefore optimum K value should be chosen keeping in mind such that image quality alters less in amount with respect to compression. Also the comparison of K-means with different compression algorithm like JPEG compression and wavelet compression is presented with their advantages and disadvantages. As observed JPEG is used generally when images are of continuous tone and it doesn’t work for binary images. Unlike JPEG wavelet works on whole image instead of segmenting image and hence produces no blocking artifacts in return.

We also observe from Table-2 that compression ratio of images using k-means algorithm is less as compared to JPEG or wavelet transform. Wavelet transform compression are performed in the same image and with changing coefficient, results are noted. Table-2 projects the difference in efficiency of each algorithm and their comparison of compression ratio and functioning.
Table-2. Comparison of K-means, JPEG and Wavelet for color image compression.

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Compression ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>K Means</td>
<td>Offers best quality image with less degradation</td>
<td>Difficult to find appropriate K value</td>
<td>5:1-10:1 (approx.)</td>
</tr>
<tr>
<td>JPEG</td>
<td>Works with colour and grey scale images. Best suited for continuous tone images.</td>
<td>Doesn’t work with binary images</td>
<td>10:1-100:1</td>
</tr>
<tr>
<td>Wavelet</td>
<td>Analyse the whole image block instead of dividing image into segment</td>
<td>Sometimes coefficients may not represent the signal with sufficient accuracy in the time domain and in the frequency domain.</td>
<td>30-300% greater than JPEG 600:1 in general</td>
</tr>
</tbody>
</table>

8. CONCLUSIONS

In conclusion, we have reviewed and summarised three algorithms named K-means, JPEG and wavelet transform. K-means provides efficient output when we transfer in bulk but are reluctant to compromise in quality. However wavelet transform provides with best compression ratio as compared to other algorithm. Compression facilitates with easy transfer of bulky images and video and then recovering of images for further use. K-means algorithm offers flexibility to compress an image by just clustering similar colours in one and then fixing appropriate value of K.

REFERENCES


