Colour Quantization

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➢ Introduction

- ✓ Vector Quantization (VQ) is an efficient technique for data compression. It has recently emerged as a powerful and efficient technique for digital speech and image coding.

- ✓ The key to VQ is the good codebook. Good codebook design leads to less distortion in reconstructed image.

- ✓ Vector Quantization is performed in three phases:
  1. Code Book Generation
  2. Image Encoding
  3. Image Decoding

- ✓ The goal of this process is data compression to minimize communication channel capacity or digital storage memory requirements while maintaining an acceptable fidelity level of the data.

- ✓ Vector Quantization works by dividing a large set of points (vectors) into groups having approximately the same number of points closest to them. Each group is represented by its centroid point, as in k-means and some other clustering algorithms.

- ✓ Color quantization is a process that reduces the number of distinct colors used in an image with the aim that the new image should be as visually similar as possible to the original image. In this we map from high resolution to lower resolution.

- ✓ In the image processing literature, the codebook obtained from K-means (the cluster centers) is called the color palette.

✓ After generation of codebook, two processes are done:-

1. **Encoding** :
    - Instead of the original data value, closest value in the alphabet of reference vectors called codebook vectors or code words is used.
    - Encoder tires to generate and assign the address of codebook vector in the codebook for the input vector.
    - For encoding, the criterion of least minimum distortion is used to generate the codebook
    - The output of the encoder is the address of searched vector.

2. **Decoding** :
    - Image is reconstructed as each pixel is represented with the most similar entry in the codebook.
    - That is, instead of the original data value, the closest value for each of the pixel in the codebook is used.
    - The decoder is only a simple (hence fast) look-up table indexed to find the closest codeword for the given input vector.

➢ Data Exploration

✓ In general, an image is represented by combining three color which are red, green and blue.

✓ Each color is encoded with 8 bits for 256 different color shades. So, each color pixel uses 24 bits of data.

✓ Image compression is done on the original image to generate a certain number of code vectors such as 256, 4096 and 65536 if each color is encoded with 8 bits, 12 bits and 16 bits respectively.

➢ Compressing image using 8 bit codebook

- ✓ In general, each color shade needs one color index for pointing the palette.
- ✓ The 24 bits of color data need about 16 million indexes.
- ✓ By using vector quantization for compression, the number of bits will be reduced in the order of 8 bits for 256 code vectors. It needs only 256 indexes for pointing 256 different color shades.

```
Size of codebook (in bytes)         :  768
Size of compressed image (in bytes):  1228800
```

- **Original Image**

```
Size of original image (in bytes):  3686400
```

- **Reconstructed Image**

```
Size of reconstructed image (in bytes):  3686400
```

✓ **Observations :**

- The reconstructed image obtained after using 8 bits codebook is represented by lesser amount of distinct colors.

- The reconstructed image looks like it lacks lots of distinct colors compared to the original image. Overall the picture tried to maintain its basic features but it lost its minute detailing. The representative colours chosen to depict the face of the person, the neck and the jacket from shoulder and neck region were not able to maintain smoothness of the picture. The major part of the left side of the background is very much clear with a small patch observed on the bottom side. On the other hand, the colours depicting the right side of the background again shows that some more distinct colours are needed to represent that part.

➢ Compressing image using 12 bit codebook

- ✓ In general, each color shade needs one color index for pointing the palette.
- ✓ The 24 bits of color data need about 16 million indexes.
- ✓ By using vector quantization for compression, the number of bits will be reduced in the order of 12 bits for 4096 code vectors. It needs only 4096 indexes for pointing 4096 different color shades.

```
Size of codebook (in bytes)         :  12288
Size of compressed image (in bytes):  1228800
```

- **Original Image**

```
Size of original image (in bytes):  3686400
```

- **Reconstructed image**

```
Size of reconstructed image (in bytes):  3686400
```

➢ **Observations :**

- The reconstructed image obtained after using 12-bit codebook looks a lot like the original one.

- The image obtained after being quantized using 12-bit codebook shows a significant improvement over the one that was reconstructed using 8-bit codebook. This is because of the representative colors being increased from 256 to 4096 which causes a lot of significant random colors to be selected for image restoration. The chosen representative colours now very well depict the face, and jacket which were not clear when the image was reconstructed using 8-bit codebook. The patch earlier visible on the left side of the background at the bottom is removed. The right side background still shows that some more colours are required to make the background smooth but overall it now maintains its basic details.

➢ Compressing image using 16 bit codebook

- ✓ In general, each color shade needs one color index for pointing the palette.
- ✓ The 24 bits of color data need about 16 million indexes.
- ✓ By using vector quantization for compression, the number of bits will be reduced in the order of 16 bits for 65536 code vectors. It needs only 65536 indexes for pointing 65536 different color shades.

Note: For 16 bit codebook, it was taking too long to execute, that is why outputs are missing.

➢ Conclusion

1. The quantized image obtained after using 12 bit codebook was better than the quantized image obtained after using 8 bit codebook. This is because the number of representative colours increases substantially with the increase of n bits on which the codebook is based.

2. Overall, with just a minimal loss of information (minute details of the image), all the three codebooks compressed and reconstructed the image with the aim of maintaining the image quality well.

3. For [MxN] pixels of color image, the proposed method provides only nx[MxN] bits instead of 24x[MxN] bits of original color image. 'n' is the selected number of binary bit for 2^n different code vectors. However, the proposed technique needs 2^nx24 bits for representing the palette of 2^n different color. Therefore, the total number of bits for this proposed method is nx[MxN]+2^nx 24 bits.