Lecture 10

Fourth stage

Medical Physical Department

Medical Imaging Processing

Interpixel Redundancy (Psychovisual Redundency) and JPEG Compression

By

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Compression Fundamentals

Data compression refers to the process of reducing the amount of data required to represent given quantity of information. Note that data and information are not the same. Data refers to the means by which the information is conveyed. Various amounts of data can represent the same amount of information. Sometimes the given data contains some data which has no relevant information, or restates/repeats the known information. It is thus said to contain data redundancy.

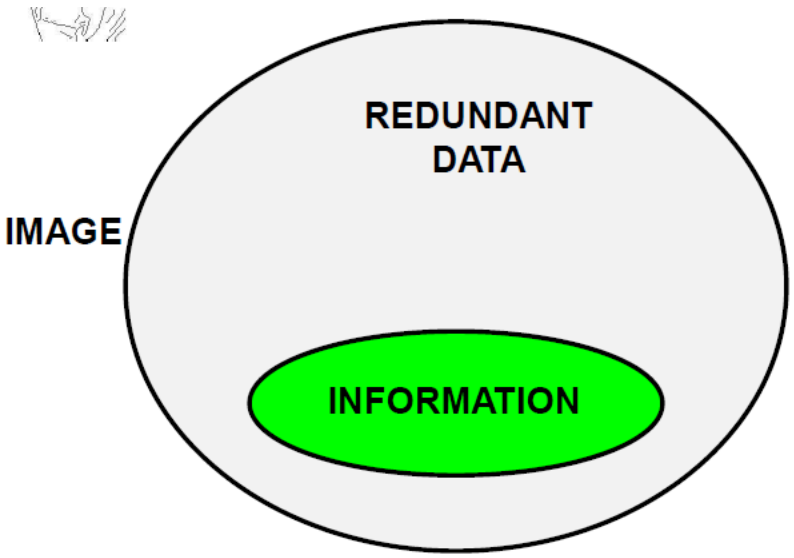


IMAGE = INFORMATION + REDUNDANT DATA

Given n1 and n2 denoting the information-carrying units in two data sets that represent the same information/image.

•The Relative data redundancy RD of the first data set, n1 ,is defined by:

$$R_D = 1 - \frac{1}{C_R}$$

•CR refers to the compression ratio and is defined by:

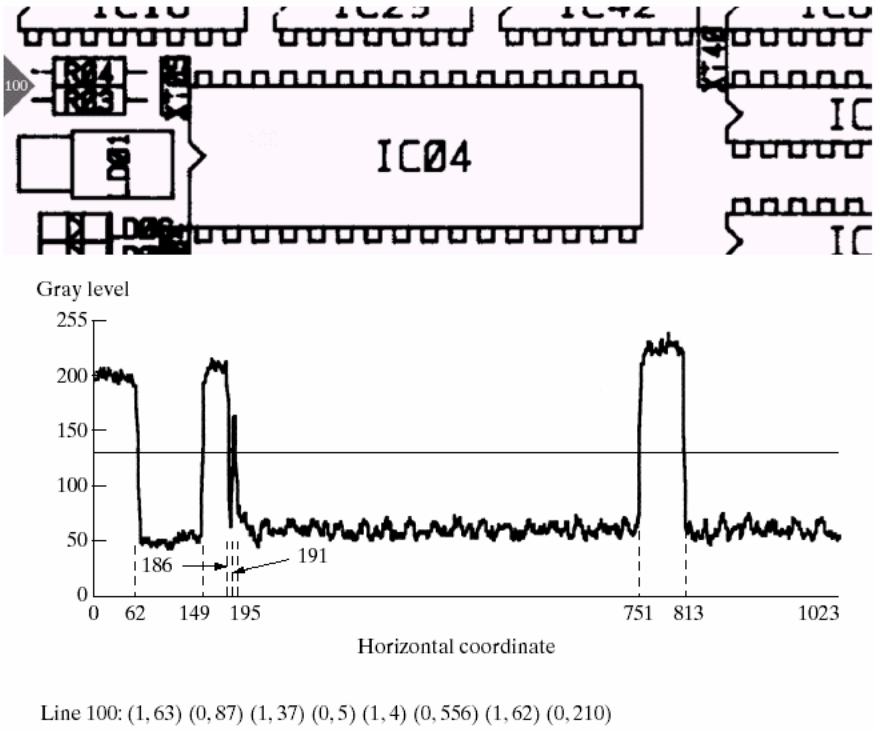
$$C_R = \frac{n_1}{n_2}$$

•If n1 = n2 , then CR=1 and RD=0, indicating that the first representation of the information contains no redundant data.

•A typical compression ratio around 10 or(10:1) indicates that 90% (RD=0.9) of the data in the first data set is redundant.

Interpixel Redundancy

This type of redundancy is related with the interpixel correlations within an image. Much of the visual contribution of a single pixel is redundant and can be guessed from the values of its neighbors.



•Given a 1024x343 binary image

•Consider a line crossing the image at line 100

•The respective line of 1024 bits can be represented by the Run-length code given at the bottom.

•Note that in this line there is 8 regions that are 1 or 0 with the specified run-length. Total of 11 bits $(1$ bit for thresholded value and 10 bit for the run length$)$ can be used to represent each of these 8 neighborhoods.

The resulting compression ratio and respective relative redundancy is given by:

1-bit for each pixel

$$C_R = \frac{(1024)(343)(1)}{(12166)(11)} = 2.63$$

Determined by thresholding each line and counting the run-length regions

$$R_D = 1 - \frac{1}{2.63} = 0.62$$

The relative redundancy is $\%62$ obtained only by using correlation among the pixels (interpixel dependencies) in the given image. This method can be extended to gray level images.

Psychovisual Redundancy

•Certain information has relatively less importance for the quality of image perception. This information is said to be psychovisually redundant.

•Unlike interpixel redundancies, the psychovisual redundancy is related with the real/quantifiable visual information. Its elimination results a loss of quantitative information. However psychovisually the loss is negligible.

•Removing this type of redundancy is a lossy process and the lost information cannot be recovered.

•The method used to remove this type of redundancy is called quantization which means the mapping of a broad range of input values to a limited number of output values.

The following example shows how an 8-bit image can be reduced to 4-bit image.

8-bit image

4-bit image
Uniform quantization
Undesired contouring effect

4-bit image
IGS quantization
No contouring effect

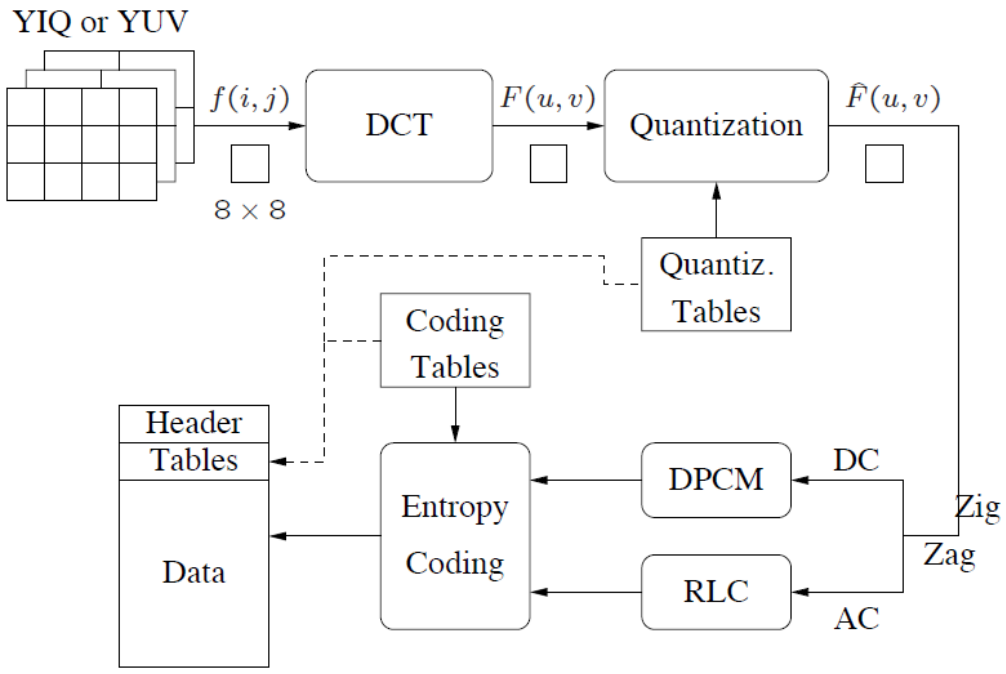
JPEG Compression

What is JPEG? "Joint Photographic Expert Group". Voted as international standard in 1992. Works with color and grayscale images, e.g., satellite, medical, ...

JPEG is an image compression standard that was developed

- JPEG is a lossy image compression method. It employs a transform coding method using the DCT (Discrete Cosine Transform).
- An image is a function of i and j (or conventionally x and y) in the spatial domain.
- The 2D DCT is used as one step in JPEG in order to yield a frequency response which is a function F(u, v) in the spatial frequency domain, indexed by two integers u and v.

2. JPEG Encoding



Decoding -- Reverse the order

Main Steps in JPEG Image Compression

- Transform RGB to YIQ or YUV and subsample color.
- DCT on image blocks.
- Quantization.
- Zig–zag ordering and run–length encoding.
- Entropy coding.