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# Lecture (10): Image quantization

**Subject: Image Processing**
**Level: Third**
**Lecturer: Asst. Lecturer Qusai AL-Durrah**

Image quantization is the process of reducing the image data by removing some of the detail information by mapping group of data points to a single point. This can be done by :

1. Gray-Level reduction (reduce pixel values themselves) I(r, c ).
2. Spatial reduction (reduce the spatial coordinate (r, c ).

The simplest method of gray-level reduction is Thresholding. We select a threshold gray -level and set everything above that value equal to "1" and everything below the threshold equal to "0". This effectively turns a gray-level image into a binary (two-level) image and is often used as a preprocessing step in the extraction of object features, such as shape, area ,or perimeter.

A more versatile method of gray -level reduction is the process of taking the data and reducing the number of bits per pixel. This can be done very efficiency by masking the lower bits via an AND operation. Within this method, the numbers of bits that are masked determine the number of gray levels available .

**Example :**

We want to reduce 8-bit information containing 256 possible gray-level values down to 32 possible values?

This can be done by ANDing each 8-bit value with the bit string 11111000 this is equivalent to dividing by eight $\mathbf{2^5}$ , corresponding to the lower three bits that we are masking and then shifting the result left three times.

[Gray- level in the image 0-7 are mapped to 0, gray-level in the range 8-15 are mapped to 8 and so on].

We can see that by masking the lower three bits we reduce 256 gray levels to 32 gray levels:

256 ÷ 8= 32

The general case requires us to mask k bits, where $2^K$ is divided into the original gray-level range to get the quantized range desired. Using this method, we can reduce the number of

gray levels to any power of 2: 2,4,8 16, 32, 64 or 128.

- Image quantization by masking to 128 gray level, this can be done by ANDing each 8-bit value with bit string 11111110($2^7$).
- Image quantization by masking to 64 gray levels. This can be done by ANDing each 8-bit value with bit string 11111100($2^6$).

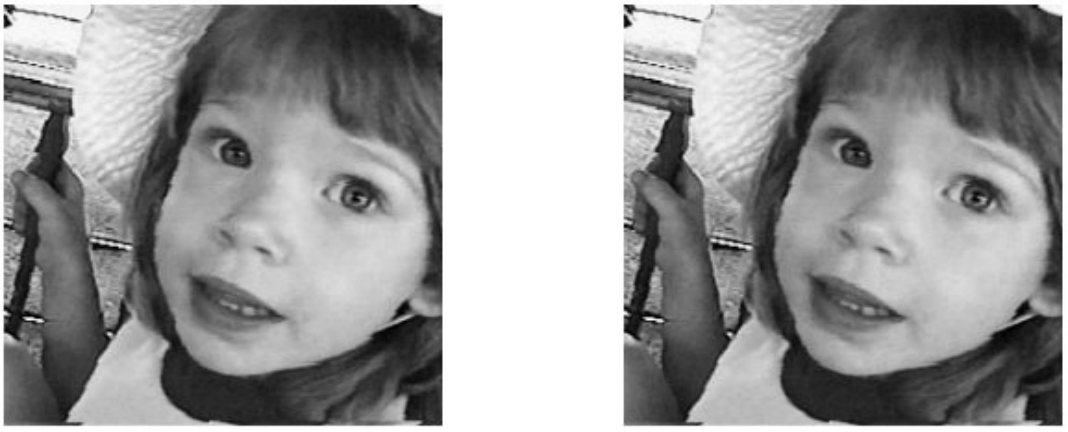



Figure (1): False Contouring

As the number of gray levels decreases, we can see increase in a phenomenon called contouring. Contouring appears in the image as false edges, or lines as a result of the gray –level.

This false contouring effect can be visually improved upon by using an IGS (improved gray-scale) quantization method. In this method (IGS) the improvement will be by adding a small random number to each pixel before quantization, which results in a more visually pleasing appearance.

Original Image

Uniform quantization
to 8 levels (3 bits)

IGS quantization
to 8 levels (3 bits)

Figure (2): IGS quantization

Ex.1\ We want to reduce 8-bit information containing (256 possible gray level) value down to 4 possible values? assume (pixel value =212), using AND-MASK.

Sol.\

1- determine (n) value:

256 gray level $\longrightarrow$ 4 gray levels.

$2^8 \longrightarrow 2^2$

n = 2

2- Extract mask:

mask = 256 - $2^{8-n}$

= 256 - $2^{8-2}$

= 256 - $2^6$ =256 - 64

mask = 192

Let g = 212 ( pixel value)

| $2^7$ | $2^6$ | $2^5$ | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ | |
|---|---|---|---|---|---|---|---|---|
| 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 | |
| 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | = 212 |
| 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | = 192 |
| 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | = 192 |

2- shift to right
no. of shift right = 8 – n

= 8 – 2 = 6

>> 6

0 0 0 0 0 0 1 1 = 3

One of black level

x = result value * $\frac{256}{4}$

= 3 * $\frac{256}{4}$

= 192

One of white level

Ex.2\We want to reduce 8-bit information containing (256 possible gray level) value down to 128 possible values. Assume (pixel value =212 ),using AND-MASK

Sol.\

1- determine (n) value:
256 gray level ⟶ 128 gray level

$2^8 \longrightarrow 2^7$

n = 7

2- Extract mask:

mask = 256 - $2^{8-7}$

= 256 - $2^{8-7}$

= 256 - $2^{1}$ =256 - 2

mask = 254

Let g = 212 (pixel value)

| $2^7$ | $2^6$ | $2^5$ | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ | |
|---|---|---|---|---|---|---|---|---|
| 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 | |
| 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | = 212 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | = 254 |
| 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | = 212 |

2- shift to right
no. of shift right = 8 – n

= 8 – 7 = 1

1 1 0 1 0 1 0 0

>> 1

0 1 1 0 1 0 1 0 = 106

One of black level

x = result value * $\frac{256}{128}$

= 106 * $\frac{256}{128}$

= 212

One of white level

**Ex.3**\ We want to reduce 8-bit information containing (256 possible gray level) value down to 4 possible values. assume (pixel value =212), using OR - MASK

Sol.\

1- determine (n) value:

256 gray level ⟶ 4 gray level

$2^8 \longrightarrow 2^2$

n = 2

2- extract mask:

mask = $2^{8-n}$ - 1

= $2^{8-2}$ - 1

= $2^6$ - 1= 64 = 63

mask = 63

Let g = 212

| $2^7$ | $2^6$ | $2^5$ | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ | |
|---|---|---|---|---|---|---|---|---|
| 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 | |
| 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | = 212 |

OR

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | = 63 |

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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | = 255 |

3- shift to right

no. of shift right = 8 – n

= 8 – 2 = 6

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| | | | | | | | >> 6 | |
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | = 3 |

One of black level

x = result value * $\frac{256}{4}$

= 3 * $\frac{256}{4}$

= 192

One of white level

Ex.1\

We want to reduce 8-bit information containing (256 possible gray level) value down to 8 possible values. AND - MASK

Ex.2\

We want to reduce 8-bit information containing (256 possible gray level) value down to 16 possible values. OR - MASK

Ex.3\

We want to reduce 8-bit information containing (256 possible gray level) value down to 64 possible values. AND - MASK

Ex.4\

We want to reduce 8-bit information containing (256 possible gray level) value down to 128 possible values. OR – MASK

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## ***Note:***

Quantization of the special coordinates results in reducing the actual size of the image this is accomplished by taking groups of pixels that are spatially adjacent and mapping them to one pixel. This can be done in one of three ways:

1- averaging, 2- median, 3- decimation.

1- averaging:

We take all the pixel in each group and find the average gray level by summing the values and dividing by the number of pixels in the group.

2- median:

We sort all the pixel values from lowest to highest and then select the middle value.

3- Decimation:

Also known as subsampling, entails simply eliminating some of the data. For example, to reduce the image by a factor of two, we simply take every other row and column and delete them. To improve the image quality when applying the decimation technique, we may want to preprocess the image with the averaging, or mean, spatial filter- this type of filtering