Tecniche per il controllo del bit/rate per immagini fotografiche e video

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Advanced System Technology

STMicroelectronics

- Introduction
- Still images
- Video sequences

Goal

Digital Still Camera Program

To ensure a file size as close as possible to a target value

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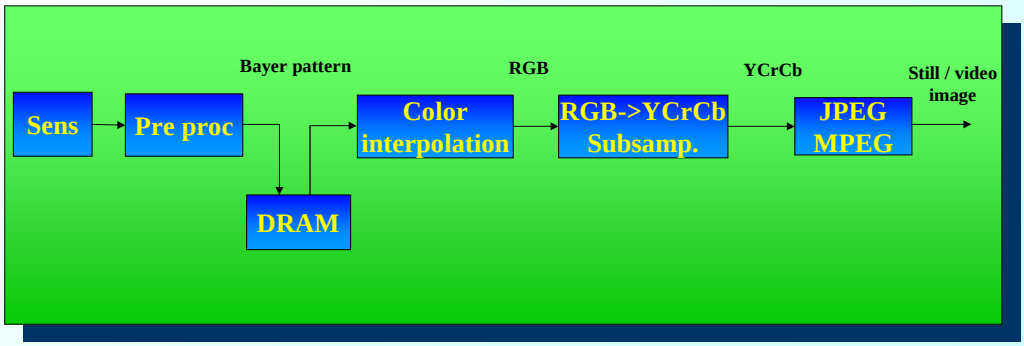
Digital Still/Moving Camera

Digital Still Camera Program



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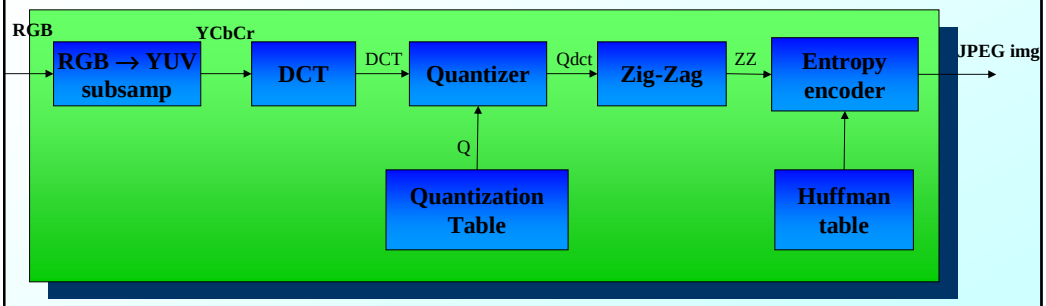
Memory requirements (still)

Sensor dim (pixel)	Size (uncompressed)
307200 (VGA)	900KB
1.3 Mpel	3.7MB
2.1 Mpel	6MB
5 Mpel	14.3MB
8 Mpel	22.8 MB

Memory requirements (video)

Sensor dim (pixel)	Size (bytes) (15 fps)
176x144 (QCIF)	1 MB/s
352x288 (CIF)	4.3 MB/s
640x480 (VGA)	13.2 MB/s
1280x720 (HDTV)	39.5 MB/s
1920x1080 (Full HDTV)	89 MB/s

JPEG


RGB
YCbCr
RGB → YUV subsamp
DCT
DCT
Quantizer
Qdct
Zig-Zag
ZZ
Entropy encoder
JPEG img
Q
Quantization Table
Huffman table

Which phases?

Digital Still Camera Program

- ✘ **Color Transform (RGB → YCbCr)**
- ✘ **Subsampling**
- ✘ **Discrete Cosine Transform**
- ✓ **Quantization**
- ✘ **DC Coefficient Encoding**
- ✘ **Zig-zag ordering of AC Coefficients**
- ✓ **Entropy Coding**

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Which phases?

Digital Still Camera Program

- Quantization phase
  Modifying the Q-tables the file size can be varied.

- Huffman phase
  Optimizing the Huffman tables the file size decrease. It is too expensive!

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How to measure

The compression factor control algorithms can be compared through three different aspects:

- Precision
- Image quality
- Speed
- Resources (Computational cost, power consumption, ...)

JPEG CF-CTRL

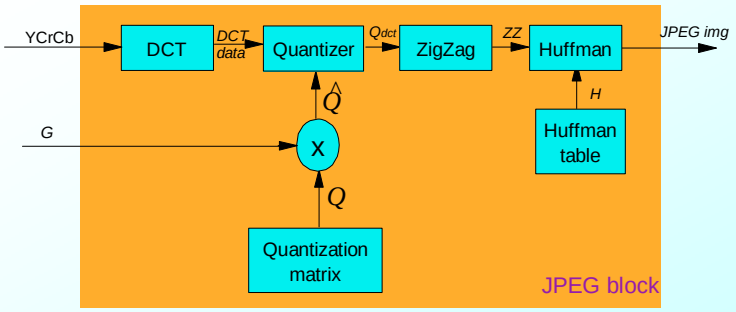
- To find the Q-tables allowing to obtain the required bit/rate.

  1) Optimize each coefficient separately in order to obtain the best quality. It is too expensive.

  2) Modify a fixed Q-table according to a multiplier value, called *Gain*

JPEG CF-CTRL

Digital Still Camera Program



$$\hat{Q} = G \cdot Q$$

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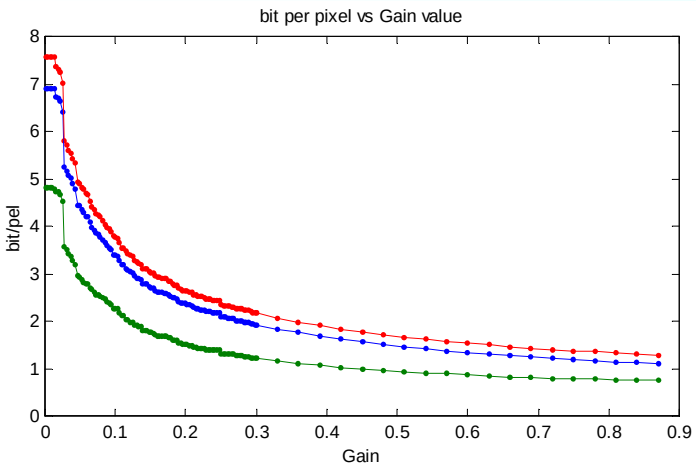
Bit rate vs Gain

Digital Still Camera Program



- The bitpel varies discontinuously according to G

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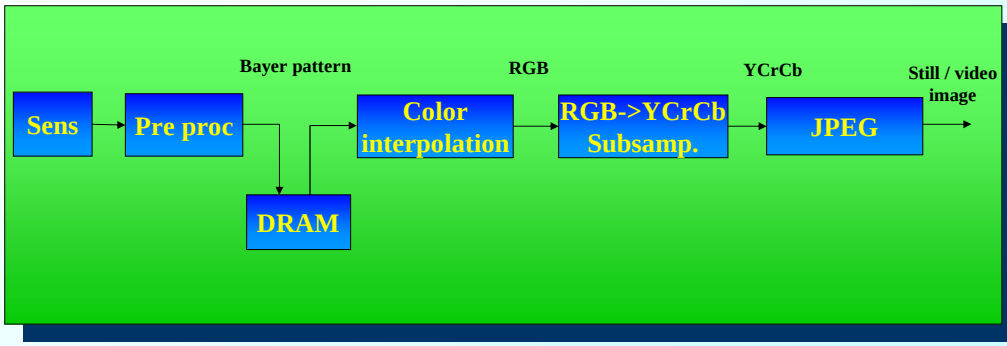
DSC without the rate control

Digital Still Camera Program



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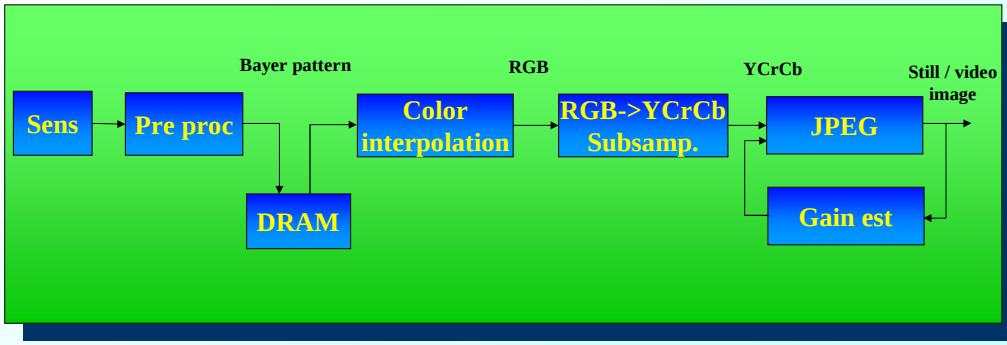
DSC with the rate control

Digital Still Camera Program



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Ideal algorithm

Digital Still Camera Program

Infinite number of cycles

- Really high precision
- Slow
- High power consumption

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Algorithms

Digital Still Camera Program

- Constant precision
- Constant cycles count

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Constant precision algorithm

- The cycle is repeated until the bit/rate is out of the prefixed precision range
- Main features:
  - The precision is always the required value
  - The time is unpredictable
  - The power consumption is unpredictable

Constant cycles number

- The cycle is repeated n-times
- Main features:
  - The precision is unpredictable (statistical range is retrieved)
  - The time is fixed
  - The power consumption is fixed

Constant precision pseudo code

Digital Still Camera Program

```
Init (threshold, G, target)
repeat
    bitrate = JPEGcompress(img, G);
    G = modifyG(bitrate, target, G);
until (abs(bitrate-target)<threshold)
```

Where:

img is the image;
G is the current gain value;
target is the target bit rate;
threshold is the required precision;
init() set the initial values;
JPEGcompress() is a function that compress the image and return the bit count;
modifyG() is the core of the rate control and modify the Gain value; according to the current results.

Constant cycles pseudo code

Digital Still Camera Program

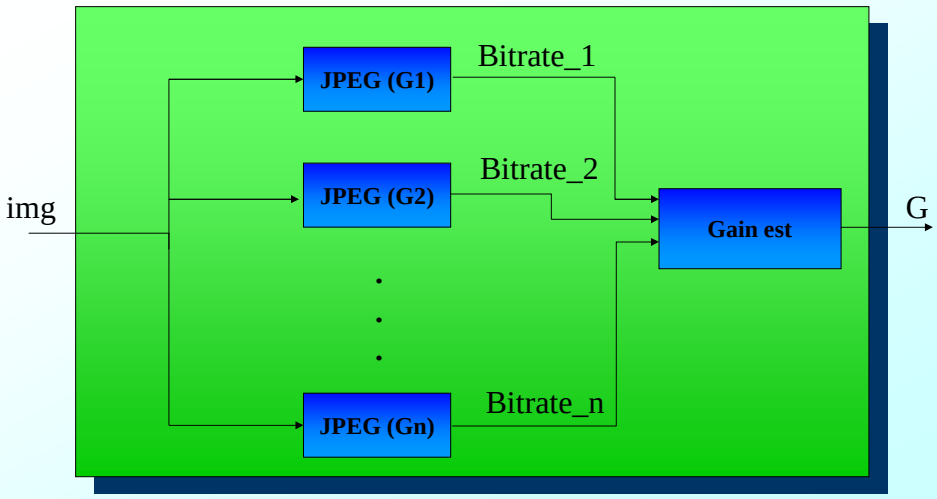
```
Init (ncycles, G, target)
for (i =1; i < ncycles; i ++)
{
    bitrate = JPEGcompress(img, G);
    G = modifyG(bitrate, target, G);
}
```

Where:

img is the image;
G is the current gain value;
target is the target bit rate;
threshold is the required precision;
init() set the initial values;
JPEGcompress() compress the image and return the bit count;
modifyG() is the core of the rate control and modify the Gain value according to the current results.

Example: Hardware solution

Digital Still Camera Program



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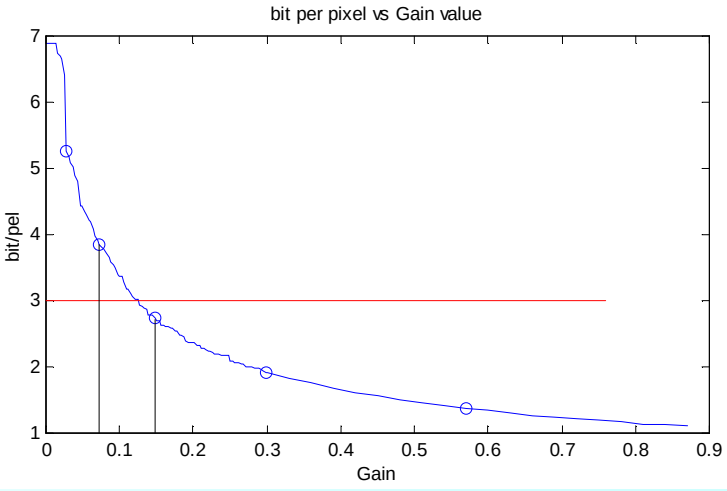
Example: The Gain est block

Digital Still Camera Program



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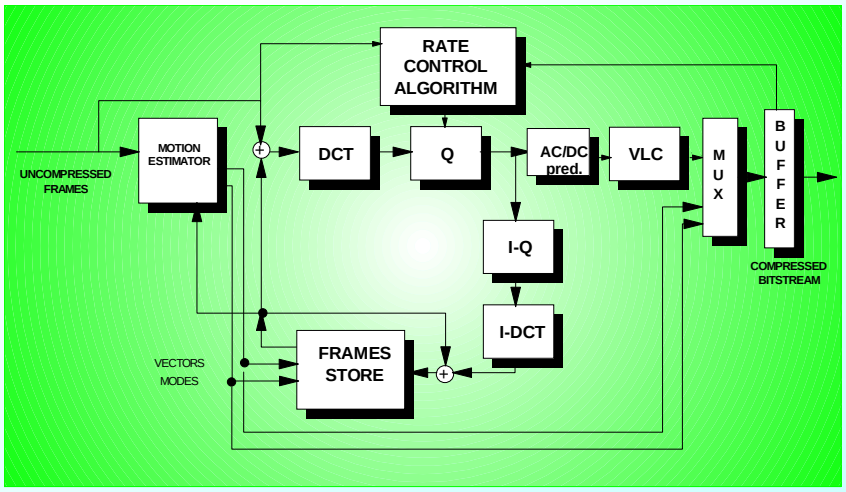
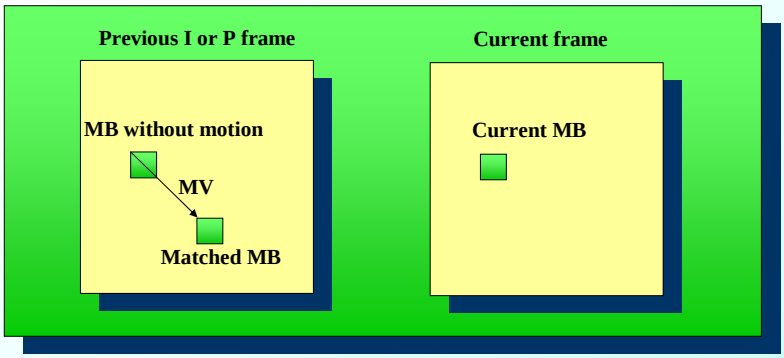
MPEG 4

MPEG4 – SP@L3



Motion estimator

Digital Still Camera Program



- Maps the current MB in the previous and the next (B frame only) encoded frame.
- Gives the Motion Vector (MV)

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DCT / I-DCT

Digital Still Camera Program

- Perform the Discrete Cosine Transform and the inverse transformation (identical to JPEG)

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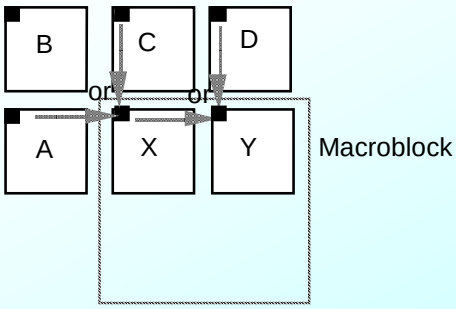
Q / I-Q

- Perform the quantization and the inverse quantization
- Two different quantization can be performed:

  1) Using a weighting matrix ;
  2) Using a fixed quantization value.

  Both the methods allow to modulate the quantization through a Quantization Parameter (QP). It can be modified at MB level.

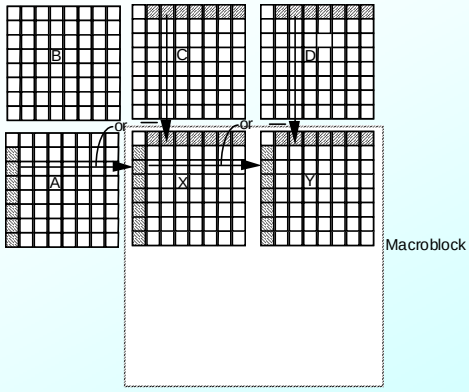
DC prediction



- The DC coeff is always predicted by the DC in the previous block or in the block above.

AC prediction

Digital Still Camera Program



- The first line's AC coeffs or the first column can be predicted by the same block used for the DC prediction

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VLC

Digital Still Camera Program

- A Run-Length / Variable Length encoder is used to compress the quantized data.
- The Huffman codes are imposed by the standard

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Which phases?

Digital Still Camera Program

- ✘ Motion estimation
- ✘ Discrete Cosine Transform
- ✓ Quantization
- ✘ DC – AC prediction
- ✘ Entropy Coding

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HOW

Digital Still Camera Program

The rate control can be performed modifying the quantization parameter (*QP*)

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Video rate control algorithms

Digital Still Camera Program

Two different kind of algorithms are developed:

1) VBR (variable bit rate)
The picture quality is important

2) CBR (constant bit rate)
The rate is important

VBR

Digital Still Camera Program

Main features:

- The QP is modified at frame level
- A constant quality picture is obtained
- The quality between adjacent frames is similar
- The rate is not ensured at frame level

Applications

- Short video messages
- Storable video

CBR

Digital Still Camera Program

Main features:

- The QP is modified at macroblock level
- A very hard rate control is performed
- A variable quality picture is obtained

Applications

- Real time applications (video conferences, …)

VBV – Video Buffer Verifier

Digital Still Camera Program

- The encoder/decoder have limited buffers for the data
- It allows to verify that the memory required in a decoder is less than the stated buffer size
- It allows to control the buffer fullness in a real time application

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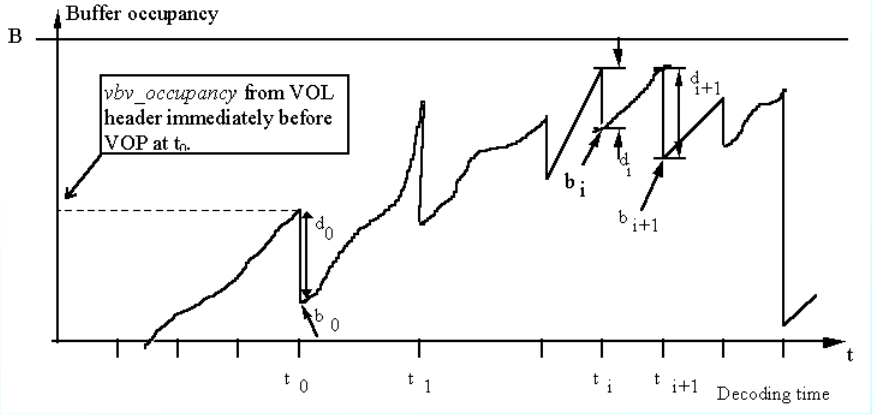
VBV buffer occupancy

Digital Still Camera Program



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