VIDEO COMPRESSION LAYER

1. COMPROMISE BETWEEN THE QUALITY AND EFFICIENCY OF VIDEO CODING

Part I of the exercise is devoted to the quantization process in the MPEG-2 standard. In the exercise the quantization matrices of coefficients for intraframe coding and interframe coding are presented.

Part II of the exercise shows main steps of a video compression process. In several steps, the main algorithms of coding are explained and tested. In the exercise the DCT coefficients, statistical properties of the DCT coefficients as well as image and prediction error properties are presented. In the exercise the efficiency of coding vs the change of DCT coefficients scan algorithm are examined. Additionally, the MPEG-2 quantization process and matrix coefficients for intra and interframe coding are examined. Lastly, an entropy coding is presented.

The i**ntra.pgm** image is the input image that is intraframe encoded, the **inter.pgm** image is the difference between the input image and the image obtained in the prediction process. The **interb.pgm** image is the difference between the input image and the image obtained in the process of bi-directional prediction. Differential images are added the constant value 128.

Average Duration

(about 1.5 hour)

Overview and Student Prerequisites

Prerequisites:

- Prerequisites for attending the course,
- Basics of MPEG video compression standard,
- Quality of video evaluation.

Technical Requirements for the Experiment

Hardware and software used in exercise:

- The software MPEG-2 coder, SDTV test sequences

Learning Outcomes

The goals:

- To get the knowledge about the lossly compression (quantization techniques in intraframe and interframe coding)
- To get experimental results on coding efficiency

Description of the Experiment

Part I - Steps of the Experiment:

Step 1.

Introduction to the contents of the quantization matrix for intraframe coding and interframe coding. In order to do this, you should use any text editor to view the **mpeg2.cfg** configuration file, and find the sections labeled **[MATRIX:INTRA_QUANT_TABLE]** and **[MATRIX:NON_INTRA_QUANT_TABLE].**
In the report, please answer the questions and explain why the template and the order of the value in the matrices are as they are presented and why these matrices vary between the different modes of coding?

Step 2.

Analysis of the quantization and inverse quantization processes in MPEG-2. Knowing that the ISO 13818-2 (MPEG-2) standard defines the cosine transform reconstruction formula In the following way:

```
for (v = 0; v < 8;v++) {
        for (u = 0; u < 8;u++) {
                if ( (u= =0) && (v= =0) && (macroblock_intra) ) {
                        F''[v][u] = intra_dc_mult * QF[v][u];
                } else {
                        if ( macroblock_intra ) {
                                F''[v][u] = ( QF[v][u] * W[w][v][u] * quantiser_scale * 2 ) / 32;
                        } else {
                                F''[v][u] = ( ( ( QF[v][u] * 2 ) + Sign(QF[v][u]) ) * W[w][v][u]
                                * quantiser_scale ) / 32;
                        }
                }
        }
}
```

please propose the equivalent process of the coefficients quantization for the encoder side. You can use a part of the ISO 13818-2 (MPEG-2) standard section 7.4 as auxiliary material.

Step 3.

The study of the coding efficiency while changing the contents of the quantization tables. Before the coding of the video you should copy the required file **v:\cfg\mpeg2.cfg** to the working directory**.** In the **mpeg2.cfg** configuration file, change the contents of an array of coefficients quantization **[MATRIX:INTRA_QUANT_TABLE]** and **[MATRIX:NON_INTRA_QUANT_TABLE]** into others coefficients eg. from matrices **v:\cfg\ sharp_q.cfg std_q.cfg** or **flat_q.cfg** configuration files.
For first 60 images of the three 4CIF test sequences: **mobile.4cif**, **fun.4cif** and **flow.4cif** check the coding efficiency with and without changes by comparing the number of bits in the image and the PSNR value of the coefficient. The coefficient quantization value for images I, P and B should be

set in the **mpeg2.cfg** configuration file of the encoder in the fields **$StartIQuant, $StartPQuant** and **$StartBQuant**. In order to encode type the following command line:

mpeg2lab –i */sciezka_na_sekwencje/nazwa_sekwencji* –l *liczba_obrazow* > wyniki.txt

Step 4.

The study of the impact and visual observation of the quantization matrix mismatch between the encoder and decoder. Compare the subjective quality of images while changing the contents of the quantization tables for three 4CIF test sequences: ***flow.4cif***, ***fun.4cif*** and ***mobile.4cif***. In order to do this, encode the images with the changed **[MATRIX:INTRA_QUANT_TABLE]** and **[MATRIX:NON_INTRA_QUANT_TABLE]** quantization tables:

mpeg2lab –i */sciezka_na_sekwencje/nazwa_sekwencji* –l *liczba_obrazow* > wyniki.txt

and decode using the MSSG reference decoder:

mpeg2dec –b mpeg2.bin –f –r –o3 wynik%#0003d

The MSSG decoder uses a standard matrix. Decoded pictures can be viewed using **iv *nazwa_pliku*.** In the report you should explain the resulting distortion.

Step 5.

In this report, please explain what is the primary objective of inverse quantization process in a decoder?

Part II - Steps of the Experiment:

Step 1.

Introduction to the statistical properties of the image and prediction error.

View the images **intra.pgm, inter.pgm, interb.pgm** and analyse the statistical properties of the values of the points in the images. Using the application **histogram,** analyse the histogram of the images using the parameters: **histogram –i */sciezka_na_obrazy/obraz_wejsciowy.pgm* –o */sciezka/obraz_wyjsciowy.hist*** and present the results using **gnuplot** with command **plot '*/sciezka/obraz_wyjsciowy.hist*'**. In the report draw the histogram and comment the results.

Step 2.

Introduction to the statistical properties of the DCT coefficients of the image and prediction error.

Using **dct** calculate the discrete cosine transformation of the images: **intra.pgm, inter.pgm, interb.pgm**. Observe the statistical properties of the coefficient magnitudes in the blocks and

explain the relation between the coefficient magnitudes and local activities (changes of a luminance level) in the appropriate part of an image. In the report comment the results.

Step 3.

Introduction to the quantization coefficient matrices for the intraframe coding and interframe coding.

Usie any text editor to view the configuration file of the coder **mpeg2.cfg.** Analyze the sections **[MATRIX:INTRA_QUANT_TABLE]** and **[MATRIX:NON_INTRA_QUANT_TABLE]**. In the report comment the form of the matrix and answer the question why the matrices are different for the intraframe coding and interframe coding.

Step 4.

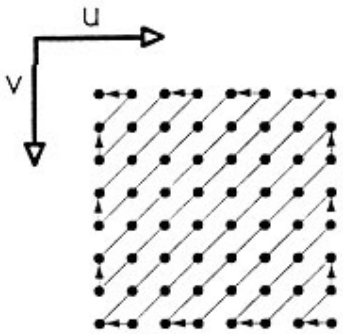
Introduction to the DCT coefficient scan matrices.

Use any text editor to view the configuration file of the coder **mpeg2.cfg.** Analyze the sections **[MATRIX:STANDARD_SCAN_TABLE]** and **[MATRIX:ALTERNATE_SCAN_TABLE]**. In the report comment the form of the matrix and answer the question when the matrix **[MATRIX:ALTERNATE_SCAN_TABLE]** should be used and why?

Step 5.

The analysis of the change of DCT scan ordering.

Compare the coding efficiency (bitrate and PSNR) for three different 4CIF test sequences ***flow.4cif***, ***fun.4cif*** and ***mobile.4cif*** while changing the DCT coefficient scan matrices. In order to do this encode the sequence using standard and changed matrices **[MATRIX:STANDARD_SCAN_TABLE]**. For this purpose replace the section **[MATRIX:STANDARD_SCAN_TABLE]** with the section included in **scan.cfg** file in **v:\cfg** directory. The matrix in **scan.cfg** file reflects the following scan order:



Use **mpeg2 –i** ***/sciezka_na_sekwencje/nazwa_sekwencji*** **–l** ***liczba_obrazow*** **> wyniki.txt**
Is using the above scan order in standard encoding process justified?

Step 6.

Introduction to variable length table codes used in MPEG-2.

Use any text editor to view the configuration file of the coder **mpeg2.cfg.** Analyze the sections denoted [VLC:*nazwa_zbioru_kodów*]. In the report comment what kind of data should be encoded via variable length code?

Step 7.

Introduction to variable length encoding process using in MPEG-2.

Use the following images for the tests: input image **intra.pgm**, directional prediction error **inter.pgm** and bidirectional prediction error **interb.pgm**. Use **dct** to calculate the discrete cosine transformation of the images **intra.pgm, inter.pgm, interb.pgm**. Quantize the transform coefficients using the **blockquant** with quantization table **mpeg2_q.cfg** with parameter q=20. Reorganize the coefficients ordering using **zigzag.** Next using **lrlcode** run-level encode the strings of the coefficients using the variable length codes. Compare the number of bits needed to encode all coefficients and put the compression ratio in the report.

Notes

1. The current directory should be set to **x:**. Before doing the exercise you should delete all the files on the drive x:\.
2. Before starting the video processing you should copy the required v:\cfg\mpeg2.cfg, v:\mpeg2_q.cfg to the directory **x:**.
3. The 4CIF test sequence are in folder **v:\4cif\.**
4. The test images intra.pgm, inter.pgm, interb.pgm are in folder **v:\pgm**.
5. After the lesson you should delete all files from the directory **x:**.