University of Brescia
School of Engineering
Master Course in Communication Technologies and Multimedia

Multimedia Communication Services

Laboratory Experience, No.6

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Contents

List of Figures

Abstract

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In the first part of this laboratory experience we loaded three frames of a QCIF video and computed three different motion estimation methods for the second frame: first using the previous one, then using the following one and at the end using an optimal combination of both other two frames.

In the second part we have computed an entropy analysis about gray level values in the original/residual images and then an entropy analysis of the motion vectors.

Motion-Compensated Prediction

Theoretical introduction

Predictive coding is widely used in video transmission, especially for low bit-rate coding. Typically only some fraction of an image changes from frame to frame allowing straightforward prediction from previous frames.
Motion compensation is used as part of the predictive process. If an image sequence shows moving objects, then their motion within the scene can be measured, and the information used to predict the content of frames later in the sequence 1.

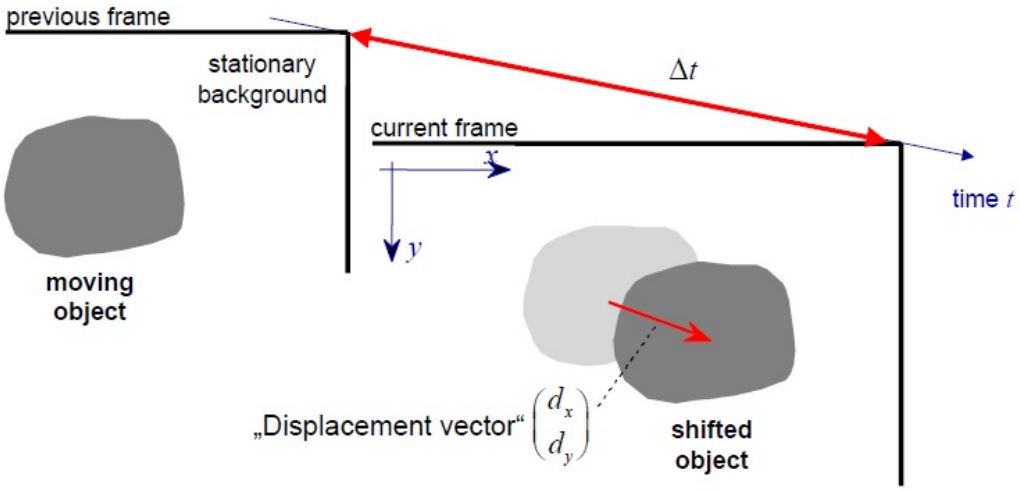

Figure 1: Moving object example.

The technique that we used is called Fixed Size Block-Matching (FSBM) 2:

- Each image frame is divided into a fixed number of usually square blocks.
- For each block in the frame, a search is made in the reference frame over an area of the image that allows for the maximum translation that the coder can use.

- The search is for the best matching block, to give the least prediction error, usually minimizing either mean square difference, or mean absolute difference which is easier to compute.

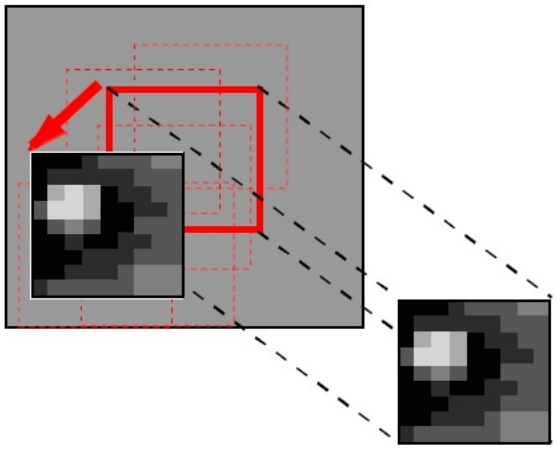

Figure 2: Fixed Size Block-Matching (FSBM).

The choice of block-size to use for motion compensation is always a compromise, smaller and more numerous blocks can better represent complex motion than fewer large ones. Typical block sizes are of the order of 16x16 pixels and so we have used these dimensions in our activities.

Prediction Results

We load a QCIF yuv 4:2:0 video, considering only the first three frames of it. 3

Figure 3: Loaded frames.

The goal of this experience is the prediction of the second frame using different reference frame and different motion-compensation techniques.

Prediction using the previous frame as a reference frame

In this method we have two step: first is the motion field estimation and the second is the compensated prediction.
We compute the motion field on the second frame with the first one as a reference. We divide the second frame in 16x16 pixel blocks and for each block we match it with the minimum error block in a 64x64 pixel region around the reference block center.
The result is in the following figure 4.

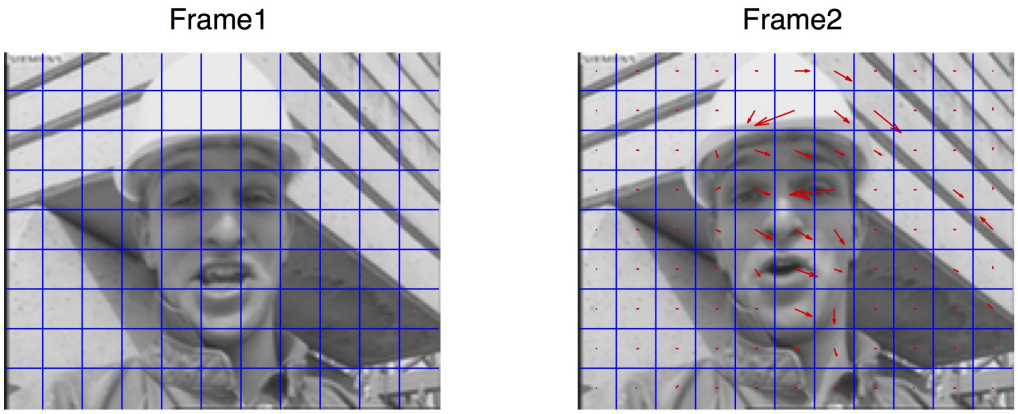

Figure 4: Motion vectors of the second frame with respect to the first one.

The second step is the motion-compensated prediction. Using the blocks matched in the previous step we estimate each 16x16 regions in the second frame. 5.

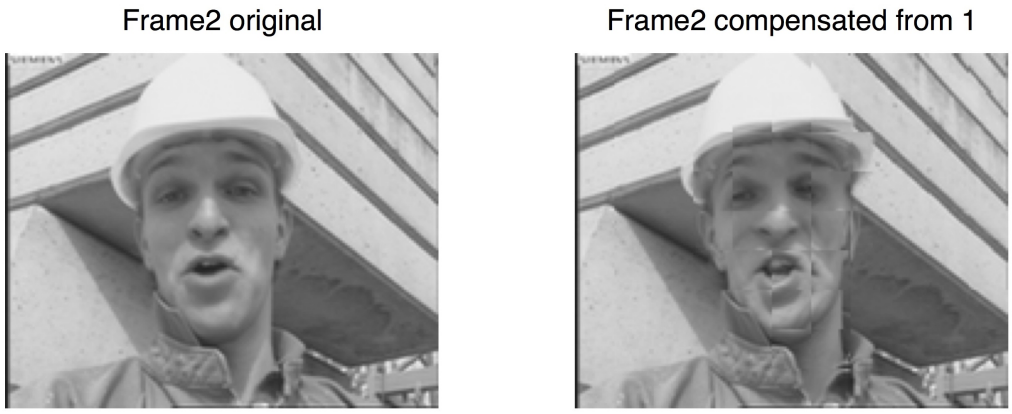

Figure 5: Second frame compensated using the motion field with respect to the first one.

Prediction using the following frame as a reference frame

In this method we use the same steps described for the the previous one but now we use the third frame like reference.
In this figure there is the result of the motion field estimation 6.

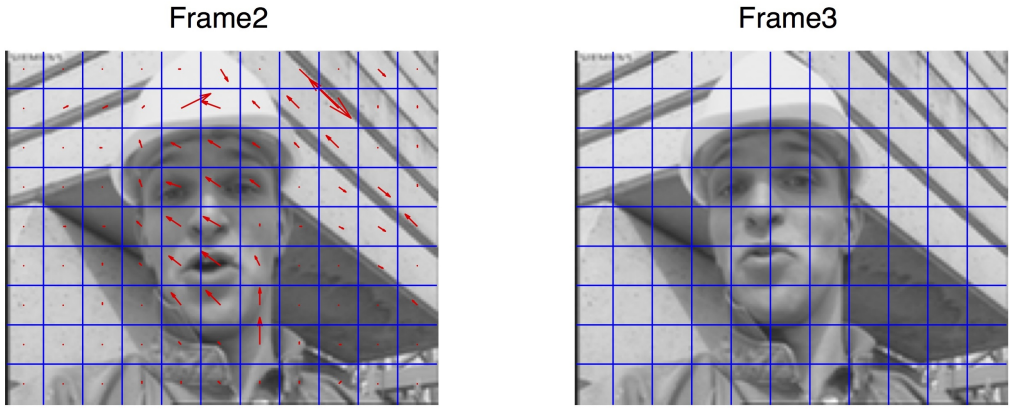

Figure 6: Motion vectors of the second frame with respect to the third one.

Whereas in the following figure there is the result of the compensation 7.

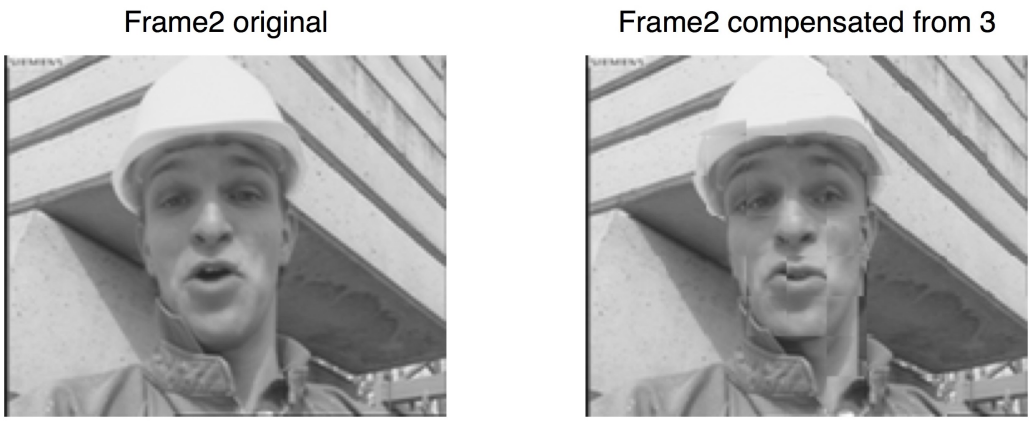

Figure 7: Second frame compensated using the motion field with respect to the third one.

Optimal prediction, using the previous and following frame as a reference frame

In this method we compute the motion field on the second frame using both the previous and the following frames, by considering, for each possible block, the optimal one among:

- Prediction from the previous frame.
- Prediction from the following frame.
- Prediction using the average between the previous and following frames (with symmetric motion vectors).

In this figure there is the result of the motion field estimation 8.

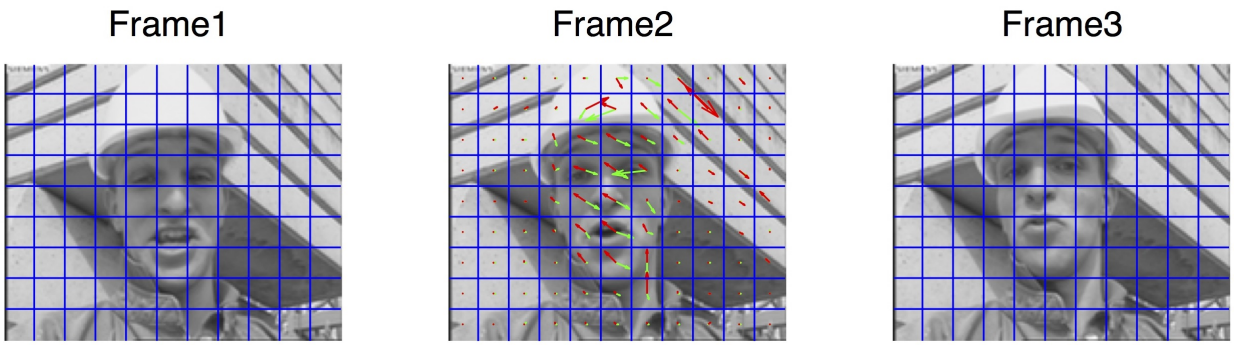

Figure 8: Motion vectors of the second frame with respect to the two other ones.

Whereas in the following figure there is the result of the compensation 9.

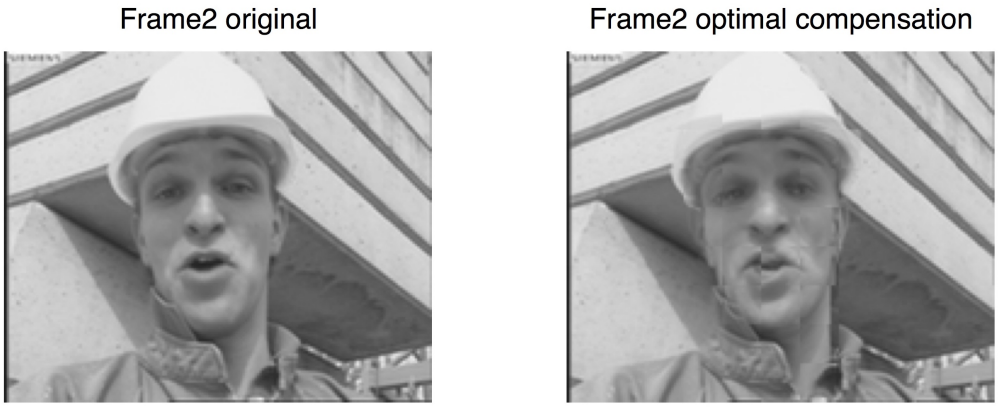

Figure 9: Second frame compensated using the motion field with respect to the two other one.

Residual Images

From the previous predicted results we can see that the third method returns the more similar frame with respect to the original second frame. This is confirmed also by the analysis of the residual images (prediction errors) and their energies. 10.

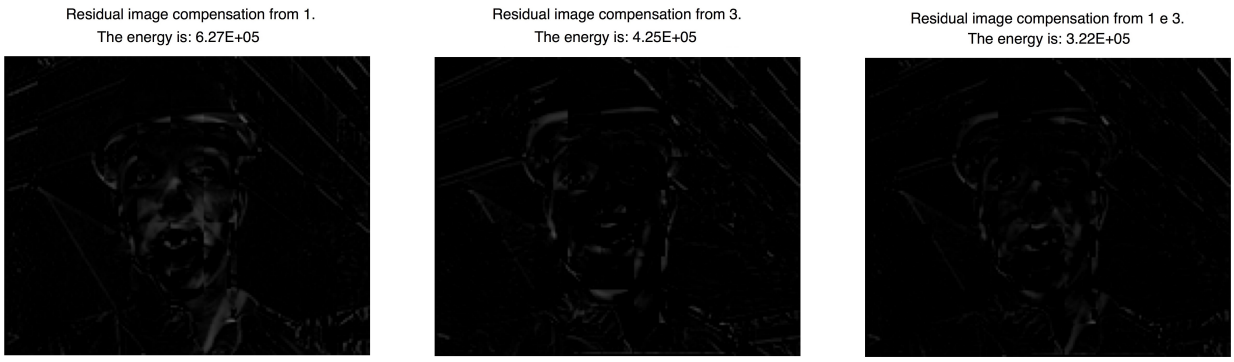

Figure 10: Residual images with respect to the three different prediction methods and relative energies.

Entropy Analysis

Gray Level Values

In this part of the laboratory experience we have computed the distribution of gray level values in the original image and in the residual images. We also have computed the entropies in each residual image and we can see that the entropy decreases with the improvement of the prediction.
In the following image the distribution (histogram) and the entropy of the residual image is shown, with a lot of error pixel around zero value (correctness of the prediction) 11.

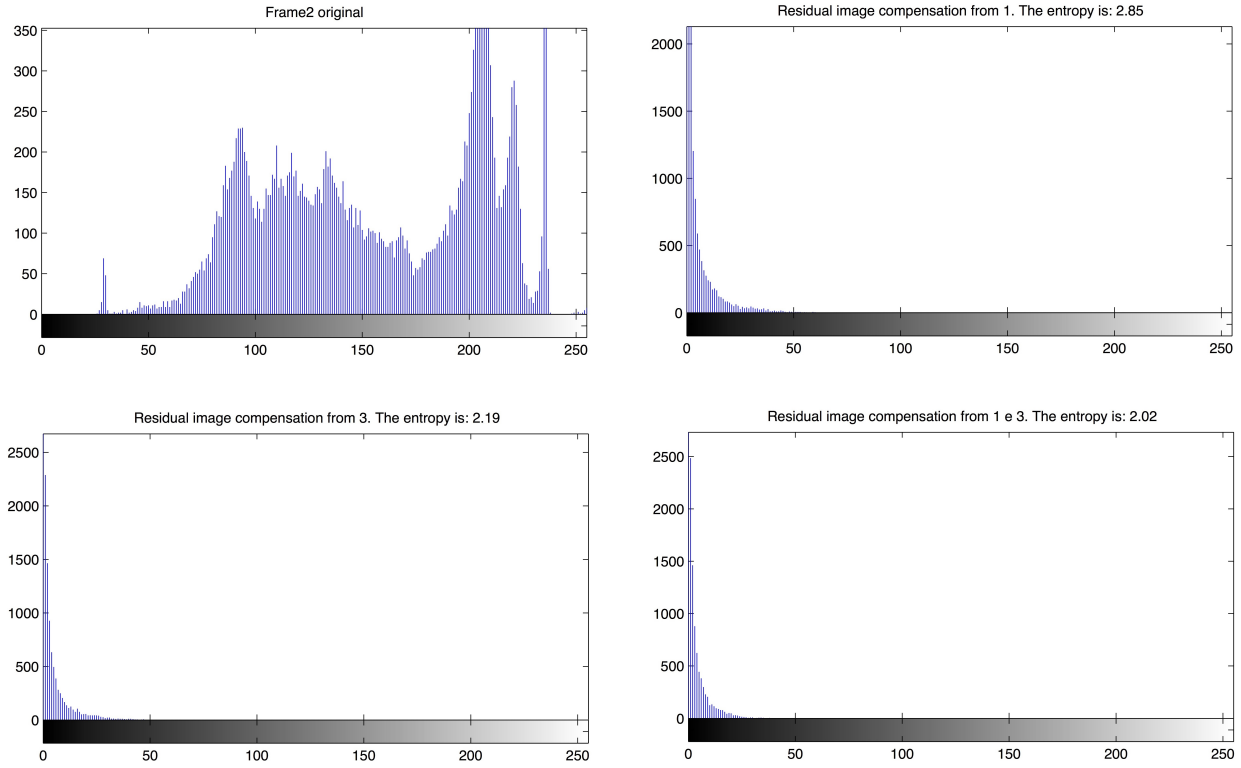

Figure 11: Pixel distributions in the original frame and in the residual images, with relative entropies.

Motion Vectors

In the last part we have analyzed the distribution of the motion vectors and computed their entropy too. We can observe that the movement values are concentrated around the zero position and it is correct evaluating two temporally neighboring frames.

In the following image we can see the distribution and the entropy of the motion field of the second frame with respect to the first one 12.

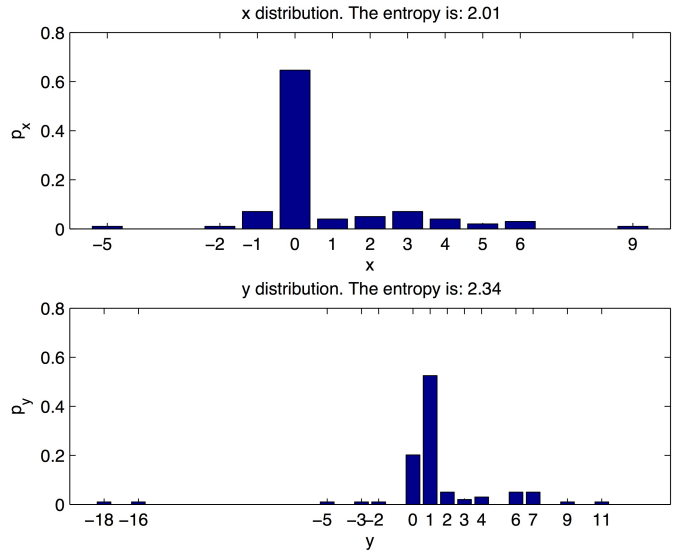

Figure 12: Motion field distributions and relative entropies.

In the following image we can see the distribution and the entropy of the motion field of the second frame with respect to the third one 13.

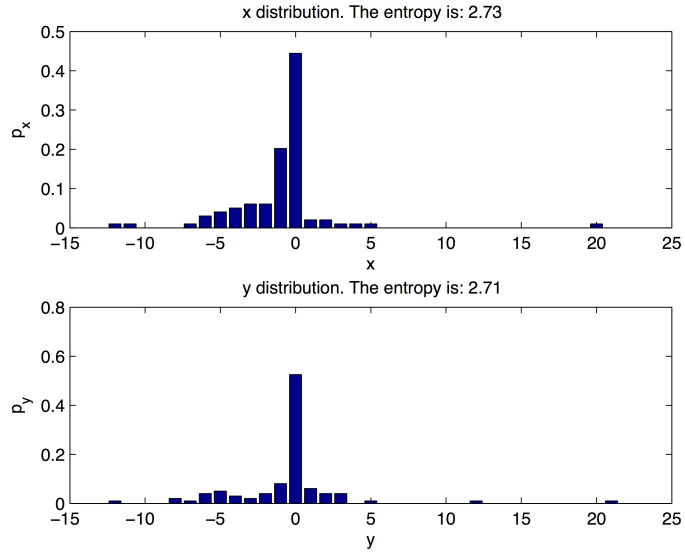

Figure 13: Motion field distributions and relative entropies.