ENEE631 F'01

Project Building-Block-3

Motion Estimation and Compensation

Due 11/08/2001 Thursday 1:59pm EDT

This assignment is a team work. The members in the team will receive the same grade, unless unbalanced contribution is noted.

Each team should hand in one hard-copy write-up with the required answers, observations, and/or inductions. Please also indicate the contribution of each team member. Your write-up should be legible and be put in the TA's mailbox by the due time. In the mean time, please create a directory of "enee631" with a subdirectory of "BB3" under your public directory and make them readable (i.e., they should be accessible via http://your-web-address/enee631/BB3/). Put the required image results and all of your source codes in this directory by the due time. Include a plain text file with filename "README.txt" to briefly explain what each image/source files included in the directory is. If the images are too large, you can use "gzip" or other lossless techniques to compress the file.

Please do this assignment using C/C++. Please see instructor if you prefer other language. No functions other than those written by you or given with this assignment are allowed to be used without instructor's permission.

Part-I. Exhaustive Block-Matching Algorithm for Motion Estimation.

In this building block, we implement the exhaustive block-matching algorithm for motion estimation. There are two video sequences can be obtained from the link below [1] and each has 10 frames. Figure-1 shows the first 2 frames of foreman sequence. For each frame pair, we define the 1st frame as a target frame (reference frame) and 2nd one as an anchor frame.

We will perform two sets of motion estimation:
[Set-1] motion estimation for frame 2-10 with frame 1 as target frame, and
[Set-2] motion estimation for frame *i* with frame *i-1* as target frame, where *i=2, …, 10.*

Complete the following tasks for each set and video sequence:

(1) To perform block matching, we first set the size of each block as N_1x N_2. For each block in the anchor frame, we calculate the MAD that is defined as follows.

$$MAD(d_1, d_2) \equiv \frac{1}{N_1 N_2} \sum_{(n_1, n_2) \in B} \left| s(n_1 + d_1, n_2 + d_2, T) - s(n_1, n_2, A) \right|$$

where B denotes an N_1x N_2 block, d_1 and d_2 are motion vectors which are integers between –R and R-1, A and T represent the anchor and target frame. The goal is to find a (d_1, d_2) pair for each block such that the MAD(d_1, d_2) is minimum. Set N_1 = N_2 = 16, R=16. Find the motion vectors for this

[1] http://www.ece.umd.edu/class/enee631/am/am4/bb3.htm

video sequence and plot them (e.g. Figure1-(d)) [2] . Put the 1st pair motion vectors in your write-up and web page.

(2) Use the motion vectors obtained above to perform estimate each frame (e.g. Figure 1-(c)) and compute the motion compensation residue. Put the 1st pair reconstructed frame and residue you obtained in your write-up and web site. You can visualize the difference in a 0-255 scale with zero difference mapped to luminance value of 128. You may also scale the difference by a factor of 5 or 10 to facilitate observation. Please calculate the 9 pairs Y-component PSNR between the original frames and reconstructed frames:

$$PSNR = \frac{255^2}{\frac{1}{M \times N} \sum_{i}^{M} \sum_{j}^{N} err[i, j]^2}$$

where M and N are the dimensions of the images

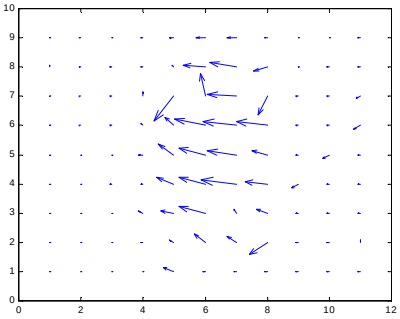
(3) Repeat (1) and (2) with R=32.

(4) Repeat (1) and (2) with $N_1 = N_2 = 8$ and R=16, 32.

(a)Foreman 1st Frame

(b) Foreman 2nd Frame

(c) Estimated 2nd Frame



(d) Motion Vectors

Figure-1 Examples of motion estimation

[2] To plot the motion vectors, you can write a subroutine by c/c++ to output these vectors, then read the files by Matlab and use *quiver.m* function to plot them.

Part-II. Compare forward and backward motion estimation and compensation

In part I, we have done the forward motion estimation and compensation (with a past frame as reference). In this part, perform backward motion estimation and compensation (with a future frame as reference), and compare the result with part I. (Set $N_1 = N_2 = 16$, R=16.). Put the 1^{st} pair of motion vectors and reconstructed frame on your write-up and web site. Calculate and compare the Y component PSNR.

Part-III. Fast Block-Matching Algorithms

Describe and implement two fast algorithms and compare the motion compensation result with that of the exhaustive search algorithm. Discuss the advantages, disadvantages, and the tradeoff for each of the three algorithms.

Part-IV. Summary

Please discuss in your report what you observe from this Building block.

[Hint: Your implementation should be done with the video codec project in mind. For example, it would be good to make your motion compensation module flexible so that you can feed in different input to realize forward and backward motion estimation.]