CS3570 Introduction to Multimedia Technology

Homework #3

Due: 11:59pm, 05/03/2024

Write a program to perform motion estimation on a provided video sequence. You have to implement two search algorithms: the Full Search method and the 2D Logarithmic Search method. For both methods, evaluate motion vectors for non-overlapping macroblocks within a search range of ±p pixels in both horizontal and vertical directions. Use the Sum of Absolute Differences (SAD) as the block matching measure.

1. Implementation and Visualization (60%)

Implement both search algorithms with search ranges of p=8 and p=16 in combination with two macroblock sizes of 8x8 and 16x16, respectively. The reference image is '00080.jpg', and the target image is '00084.jpg'.

a. Generate and display the predicted images by using the block matching for all the above combinations (8 images in total)

b. Show the motion vectors images for all the above combinations (8 images in total)

c. Convert the target and predicted images to single-channel images by extracting the luminance (Y) component from the YCbCr color space. Then, display the residual images calculated from these luminance-only images for all the above combinations (8 images in total)

d. Compute the total SAD values and PSNR for all the results

e. Compare and discuss the motion-based image prediction quality for all the above settings

2. Temporal Performance Analysis of Motion Estimation (30%)

Implement the 2D Logarithmic Search method across an entire video sequence using a search range of p=16 and macroblock size of 16x16. The sequence starts with the reference frame '00050.jpg', and subsequent frames in the video serve as target images.

a. Plot the curves of the total SAD and PSNR across the video sequence to capture the performance metrics dynamically and describe what you observe

b. Generate predicted images and residual images for each frame in the sequence in relation to the reference frame and compile them into two video files to visualize the temporal consistency of the motion estimation

3. Computational Efficiency Analysis (10%)

a. Measure the execution time required for the two search algorithms with the two different search range sizes p=8 and p=16

b. Compare and discuss the execution time with the theoretical time complexity for the two search algorithms

Remainder

- You are not allowed to use any function that directly generates the result for each step, except for those provided by us

- Your code should work correctly and the generated results must be consistent to your results in report

- If you encounter any problems or have questions, please post them on eeclass

- Homework should be submitted before the announced due time. Score of the late one will be reduced by 20% per day

- Please compress your code and results in a zip file named HW3_{StudentID}.zip and upload to eeclass

- Please follow the file structure below:

```
./HW3_000000000/
├── HW3_000000000.ipynb
└── out
    ├── Q1
    │   ├── 2d_log_search_motion_vector_r16_b16.jpg
    │   ├── 2d_log_search_motion_vector_r16_b8.jpg
    │   ├── 2d_log_search_motion_vector_r8_b16.jpg
    │   ├── 2d_log_search_motion_vector_r8_b8.jpg
    │   ├── 2d_log_search_predicted_r16_b16.jpg
    │   ├── 2d_log_search_predicted_r16_b8.jpg
    │   ├── 2d_log_search_predicted_r8_b16.jpg
    │   ├── 2d_log_search_predicted_r8_b8.jpg
    │   ├── 2d_log_search_residual_r16_b16.jpg
    │   ├── 2d_log_search_residual_r16_b8.jpg
    │   ├── 2d_log_search_residual_r8_b16.jpg
    │   ├── 2d_log_search_residual_r8_b8.jpg
    │   ├── full_search_motion_vector_r16_b16.jpg
    │   ├── full_search_motion_vector_r16_b8.jpg
    │   ├── full_search_motion_vector_r8_b16.jpg
    │   ├── full_search_motion_vector_r8_b8.jpg
    │   ├── full_search_predicted_r16_b16.jpg
    │   ├── full_search_predicted_r16_b8.jpg
    │   ├── full_search_predicted_r8_b16.jpg
    │   ├── full_search_predicted_r8_b8.jpg
    │   ├── full_search_residual_r16_b16.jpg
    │   ├── full_search_residual_r16_b8.jpg
    │   ├── full_search_residual_r8_b16.jpg
    │   └── full_search_residual_r8_b8.jpg
    └── Q2
        ├── predicted.mp4
        └── residual.mp4

3 directories, 27 files
```