

Write a program to perform motion estimation on a provided video sequence. You will have to implement three search algorithms to find the motion vectors, the **Full Search** method, **2D Logarithmic Search** method and **Three-Step Search** method. For the methods, estimate motion vectors for non-overlapping macroblocks within a search window of  $\pm p$  pixels in both the horizontal and vertical directions. Use the **Sum of Absolute Differences (SAD)**, which is described on slide (p.44), as the metric for block matching.

1. **(50%)** Try the two search ranges (**p=8 and p=16**) for two macroblock sizes (**8x8 and 16x16**) by using **Full search** and **2D Logarithmic Search** methods. The reference image is **008.jpg**, and the target image is **009.jpg**.
  - a. Generate and show 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 of the above combinations (**8 images in total**)  
(The motion vector is drawn on the **target image**)
  - c. Show the residual images (in RGB) 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. **(20%)** Try **all three methods** across the entire image sequence using a search range of **p = 8** and macroblock size of **16x16**. The reference image is **000.jpg**, and the target images are the image sequence which **starts from 001.jpg to 017.jpg**.
  - a. Plot the curves of the total SAD and PSNR across the image sequence of **all three methods** to capture the performance dynamically and describe what you observe. Make sure to **show the curves in your report**.
3. **(15%)** Try the **2D Logarithmic Search** method with search range **p = 8** and macroblock sizes of **16x16**. The reference image is **008.jpg** and the target image as **012.jpg**.
  - a. Show the total SAD and PSNR of the result. Compare and discuss the total SAD and PSNR with the result of same search range and macro block in question 1.
4. **(15%)** Time Complexity Analysis
  - a. Measure the execution time required for the three 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 three search algorithms

## Reminder

- You need to implement your own functions for computing SAD and PSNR between two images.
- Your code should work correctly and the generated results must be consistent to your results in report
- In report, should contain at least all the results (**predicted images, motion vectors images, residual images, total SAD values, PSNR values**) mentioned in the problem, brief explanation of your implementation and the discussion to the output results.
- Homework should be submitted before the announced due time. Score of the late ones will be reduced by 20% per day
- Please compress your code and results in a zip file named HW3\_{StudentID}.zip and upload to eclass.
- Please follow the file structure below

HW3\_109060000

```
|—— hw3.py or hw3.ipynb
|—— img (18 images)
|   |—— 000.jpg
|   |—— 001.jpg
|   |—— 002.jpg
|       .....
|   |—— 016.jpg
|   |—— 017.jpg
|—— out
|   |—— full_predicted_r8_b8.jpg
|   |—— full_predicted_r8_bl6.jpg
|   |—— full_predicted_r16_b8.jpg
|   |—— full_predicted_r16_bl6.jpg
|   |—— full_motion_vector_r8_b8.jpg
|   |—— full_motion_vector_r8_bl6.jpg
|   |—— full_motion_vector_r16_b8.jpg
|   |—— full_motion_vector_r16_bl6.jpg
|   |—— full_residual_r8_b8.jpg
|   |—— full_residual_r8_bl6.jpg
|   |—— full_residual_r16_b8.jpg
|   |—— full_residual_r16_bl6.jpg
|   |—— 2d_predicted_r8_b8.jpg
|   |—— 2d_predicted_r8_bl6.jpg
|   |—— 2d_predicted_r16_b8.jpg
|   |—— 2d_predicted_r16_bl6.jpg
|   |—— 2d_motion_vector_r8_b8.jpg
|   |—— 2d_motion_vector_r8_bl6.jpg
|   |—— 2d_motion_vector_r16_b8.jpg
|   |—— 2d_motion_vector_r16_bl6.jpg
|   |—— 2d_residual_r8_b8.jpg
|   |—— 2d_residual_r8_bl6.jpg
|   |—— 2d_residual_r16_b8.jpg
|   |—— 2d_residual_r16_bl6.jpg
|—— report.pdf
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