Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

4C8 – DIGITAL IMAGE AND VIDEO PROCESSING

Lab 4 – Motion

Department of Electrical and Electronics

(e-Report submission)

Table of Content

Submitted by:

Rohan Taneja
19323238

Submission: 16/04/2021

1. Block Matching

1.1. Block with minimum MAE DFD

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Find the block with minimum DFD, save it to mc_block
% and assign its offset to 'motion_x(ny,nx)'
% and 'motion_y(ny,nx)'

diff_block = abs(other_block - ref_block);
mae = mean(diff_block(:));

if ( mae < min_error_ )
    mc_block = other_block; min_error_ = mae;
    motion_x(ny,nx) = ii; motion_y(ny,nx) = jj;
end

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

Before definition of Motion Compensated Block we require computation of Mean Absolute Error of Reference (current) and Other (offset) block. Based on the calculation of MAE, we store the offset block with respective lowest DFD.

```
>> testBlockMatching

reading video file:       OK
running blockmatching:    OK
DFD:                      OK
vectors x:                OK
vectors y:                OK
```

On testing the *blockmatching function* on given *testBlockMatching script* we obtain the results as shown.

2. Motion Compensation Error

Before proceeding 2.1 and ahead. The defined parameters are listed in the image below:

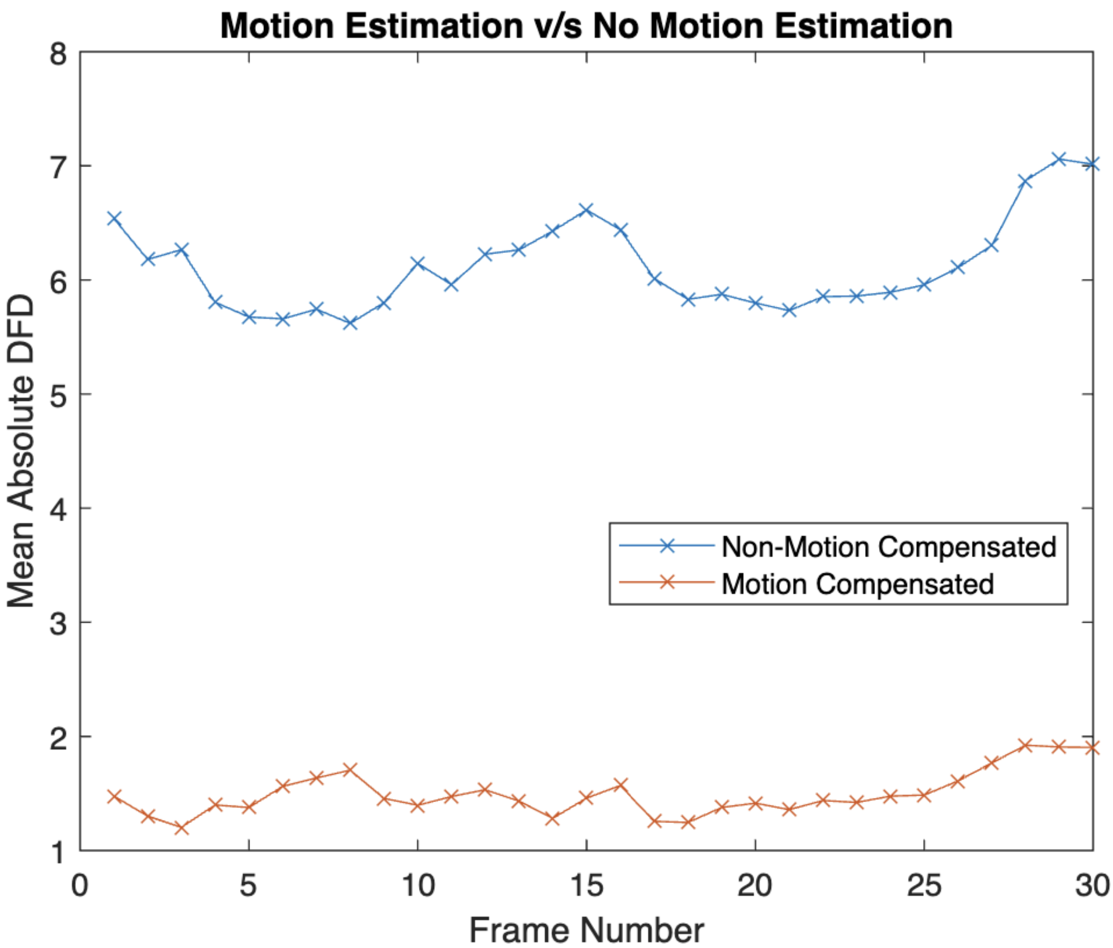
```
%%%%%%%%%%%%%%% parameters etc %%%%%%%%%%%%%%%%%%%%%%%%

filename    = './qonly.360x288.y';
hres        = 360;  % horizontal size
vres        = 288;  % versical size
B           = 16;   % block size
w           = 4;    % window search range is +/-w
mae_t       = 2;    % motion threshold MAE per block
start_frame = 1;
nframes     = 30;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

2.1. MAE Computation for Motion vs Non-Motion Estimation

Plotting the graph for comparing MAE in Motion Estimation v/s No Motion Estimation. The plot below depicts computed MAE frame-by-frame with blue for Non-Motion Compensated DFD and orange for Motion Compensated DFD. The scaling for y-axis is in order of e-5 for this plot.



3. Analysis

Before proceeding with analysis. The sample code attached was used to plot task 2.1 and further plots discussed in the analysis.

```
% initialize error parameters & for-loop for plots
mc_error = (nframes); non_mc_error = (nframes);
figure;
for mae_t = [1 2 4 8]
    for frame = start_frame:start_frame+nframes-1
        fseek(fin,hres*vres*(frame-1),'bof');
        past_frame = double(fread(fin,[hres vres],'uint8')');

        fseek(fin,hres*vres*frame,'bof');
        curr_frame = double(fread(fin,[hres vres],'uint8')');

        % calc motion & non-motion compensated DFD
        [~,~,mc_dfd] = blockmatching(curr_frame, past_frame, B, w, mae_t);
        non_mc_dfd = abs(curr_frame-past_frame);

        mc_error(frame) = sum(mean(abs(mc_dfd(:))))/numel(mc_dfd);
        non_mc_error(frame) = sum(mean(non_mc_dfd(:)))/numel(non_mc_dfd);
    end
    plot((start_frame:nframes),mc_error, '-x'); hold on;
end
plot((start_frame:nframes),non_mc_error, '-x');
```

3.1. Compare & Contrast Original Frames with DFD

From the results as obtained in 2.1 – we can observe that for the initial four frames the results are expectedly comparable in both motion (DFD) and no motion estimation (original). For the defined parameters – the trend disrupts block matching resulting in opposite impact until 15th frame. Later the pattern observed for blockmatching to work is spot on.

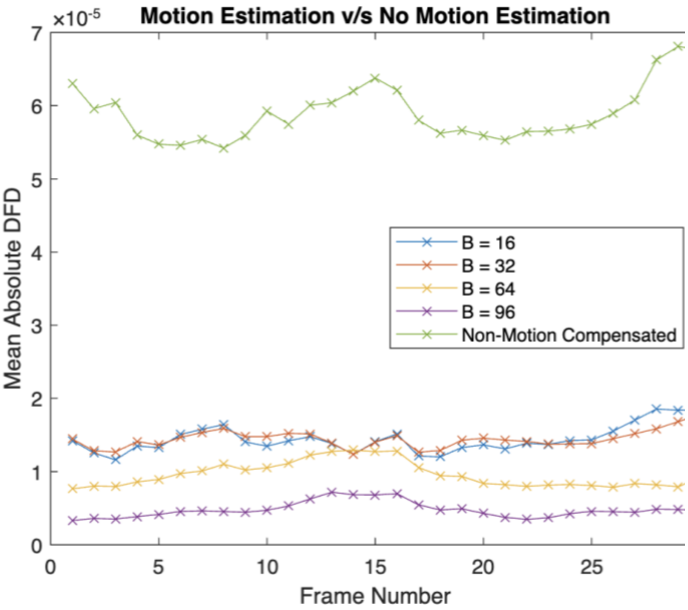
Blockmatching comes at a cost to due to pathological motion taking place within the compared frames. Few examples of such motions are data cut-off between the frames, reflective or transparent motion within the frame or expected motion blur in relevance to fast motion (beyond window search size).

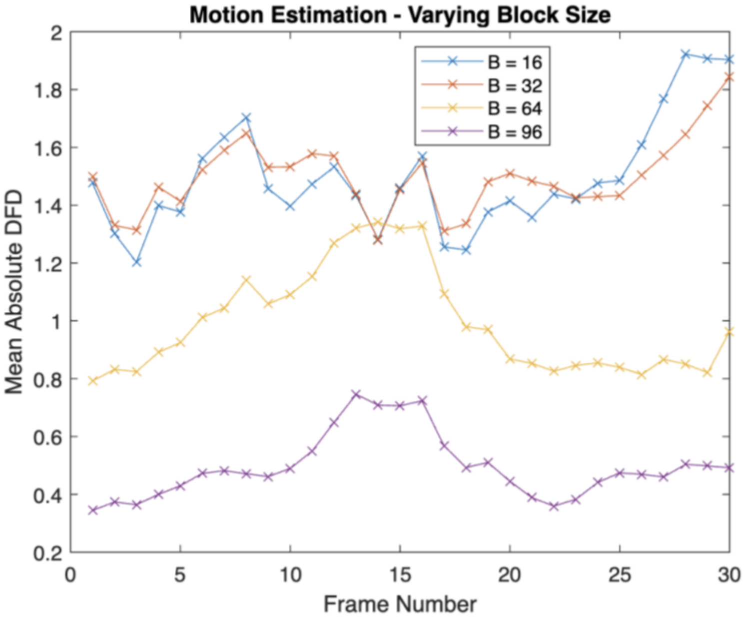
3.2. Ranking based on Performance & Computation

Ranking in terms of performance of blockmatching and computational efficiency would make further sense comparing same parameters on different tested values. The expected behaviour observed can be further commented on analysing the results obtained.

a) Varying Block Sizes for Block Matching

Plot on the left – Comparison with No Motion Estimation
Plot on the Right – scaling on y = e-5 – Only Motion Estimation for a)





Performance – With Increasing Block Size (compatible with the resolution of input frame) – higher performance is observed.

Computation Time – Larger Block Size, Lower the number of computational operations and blocks matched

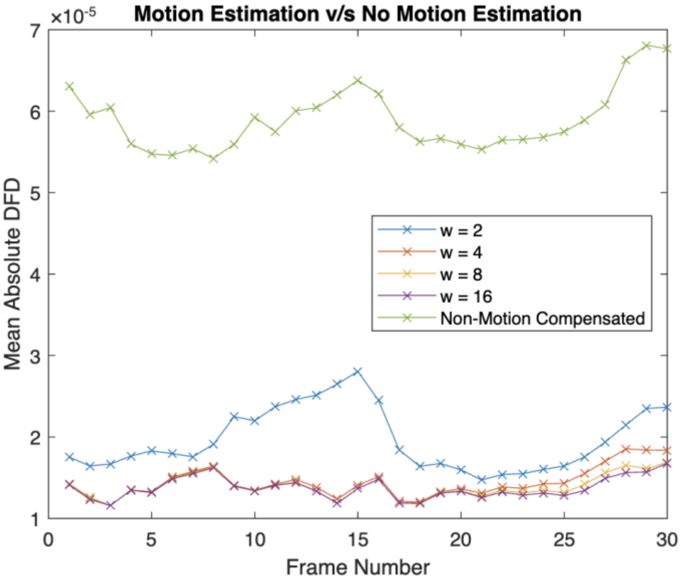
```
Elapsed time is 2.366312 seconds.
Elapsed time is 0.790605 seconds.
Elapsed time is 0.204075 seconds.
Elapsed time is 0.121842 seconds.
```

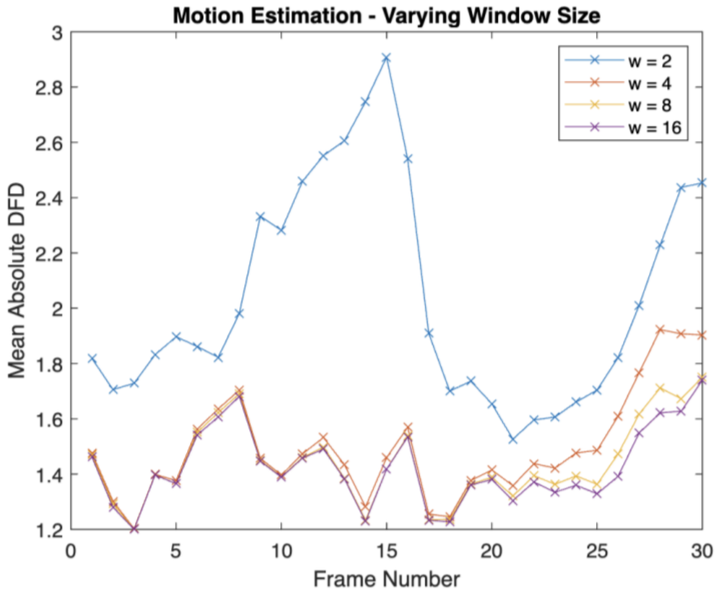
MAE – Decreases with Increasing block size since there is an inverse impact.

Motion Field – Shorter the magnitude of DFD MAE – less defined motion fields are expected.

b) Varying Window Search Size

Plot on the left – Comparison with No Motion Estimation
Plot on the Right – scaling on y = e-5 – Only Motion Estimation for b)





Performance – Higher Window Search Size costing towards lower performance.

Computation Time – Increasing window search size results in more computational operations

```
Elapsed time is 1.091615 seconds.
Elapsed time is 2.388175 seconds.
Elapsed time is 7.771385 seconds.
Elapsed time is 29.147745 seconds.
```

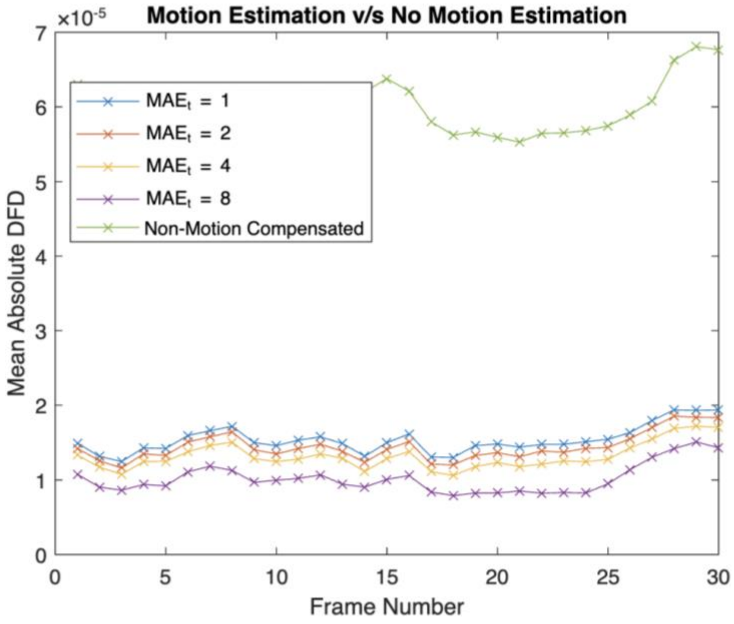
MAE – Window search size directly impacts the computation of mean absolute error as DFD decreases with its increase.

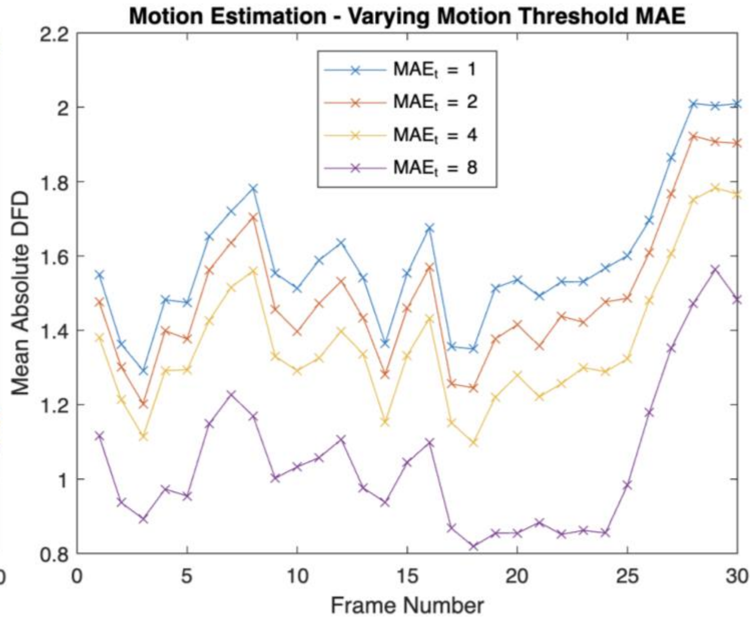
Motion Field – For small window search size – expected motion field is well defined.

Smaller search window size resulted in comparable results for block matched frames v/s no motion estimation applied with reduced MAE.

c) Varying Motion Threshold

Plot on the left – Comparison with No Motion Estimation
Plot on the Right – scaling on y = e-5 – Only Motion Estimation for c)





Performance – Higher Threshold results in Lower Quality – Higher Performance

Computation Time – Increasing Threshold results in less computational operation

```
Elapsed time is 2.908091 seconds.
Elapsed time is 2.373353 seconds.
Elapsed time is 2.210231 seconds.
Elapsed time is 1.224321 seconds.
```

MAE – Directly impacted with increase in threshold.

Motion Field – Higher the threshold shorter motion field as observed.

Behaviour expected is similar throughout tested threshold values.

Conclusion

Overall drop in entropy is observed when each parameter tested is increased but effects negatively when block matching is inefficient on the applied frames. So, correct parameters implementation is important.

Performance Ranking: Window Search > Threshold > Block Size

Computational Efficiency: Block Size > Threshold > Window Search