Assignment 2

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Exercise 1

1.1 RDO Optimization Metrics for Varying Intra Periods

The following features were added to the encoder

- Intra frame prediction with variable intra periods
- Discrete cosine transform of residual data
- Quantization of transform coefficients
- Coefficient reordering, run length encoding and entropy encoding of the QTC coefficients
- Differential and entropy encoding of the MDIFF data

The decoder was also updated to do the reverse operations needed to decode the data in its new bitstream form.

1.1.1 R-D plots with RDO disabled

The following R-D plots show the first 10 Frames of Foreman CIF. The measured bitrates were calculated using the summation of the QTC and MDIFF data bits. The PSNR is the average PSNR over the 10 frames. The plots were generated with RDO disabled, using the default motion estimation algorithms.

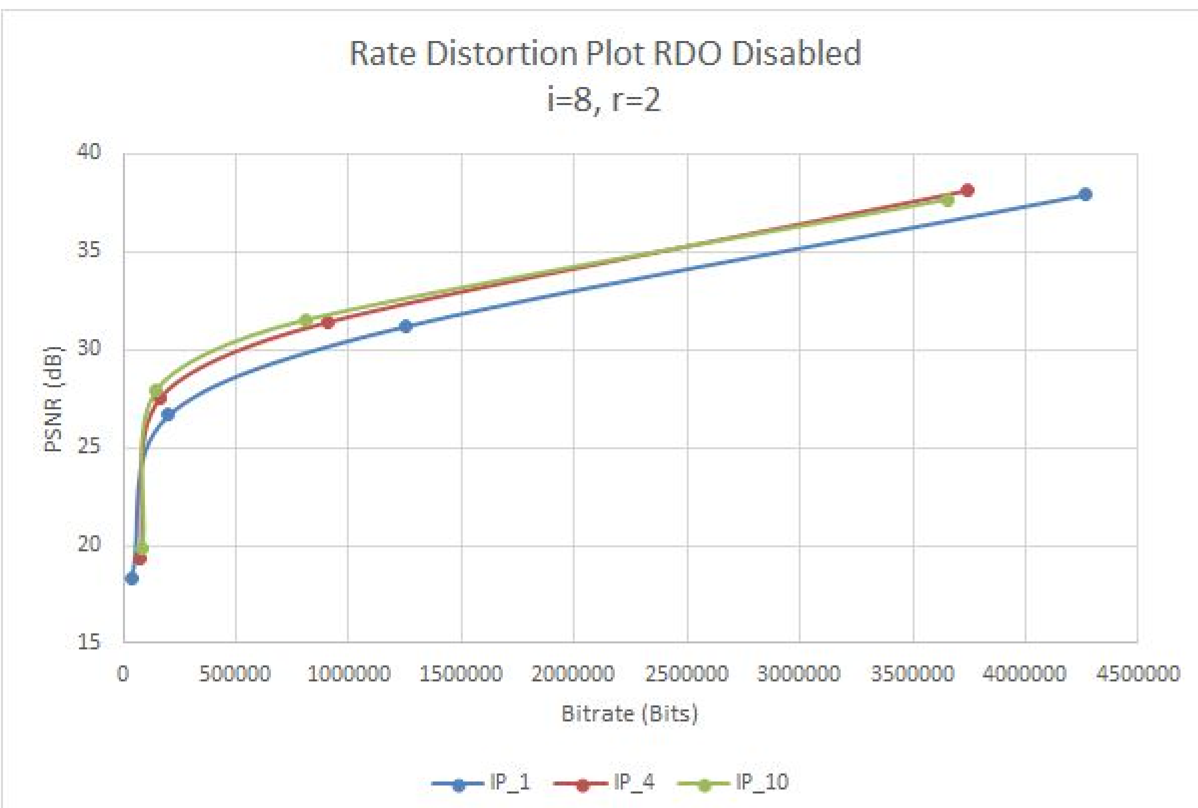

Figure 1: R-D plot for i = 8, range = 2, for different i_periods (IP), RDO disabled

Figure 2: R-D plot for i = 16, range =2 for different i_periods (IP), RDO disabled

Figure 3: Run time for RDO disabled for different Intra Periods

1.1.2 R-D plots with RDO enabled

We observed that for high QP values, the size of the MDIFF data was becoming a bigger contributor to the overall filesize. We also saw that for a high QP, block values are quantized to a point where the choice in blocks is not as important, since most blocks would yield a similar quality. Therefore we decided to optimize for high QP values (greater than 6). To achieve this, we decided that during inter frame prediction motion search, we would do the search for the first block in the row, and then for the remaining blocks in the row, encode the same gmv vector. This allowed for better differential encoding of MDIFF data, with a very small degradation in quality.

The following R-D plots show the first 10 Frames of Foreman CIF. The measured bitrates were calculated using the summation of the QTC and MDIFF data bits. The plots were generated with RDO enabled, using motion estimation estimation algorithms that would optimize the RD curve.

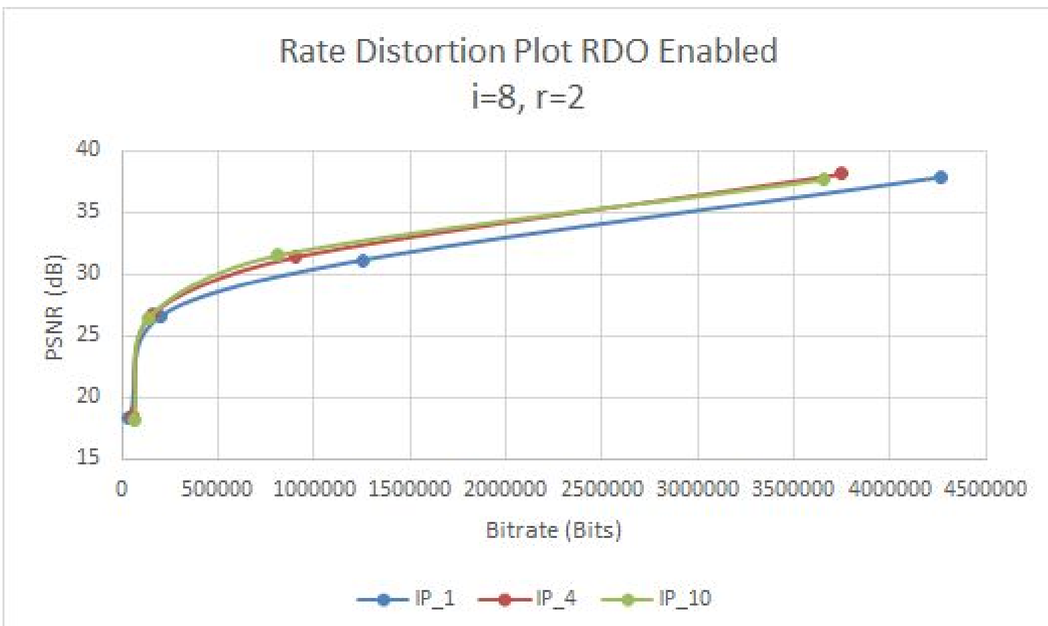

Figure 4: R-D plot for i = 8, range = 2, with varying i_period, RDO enabled

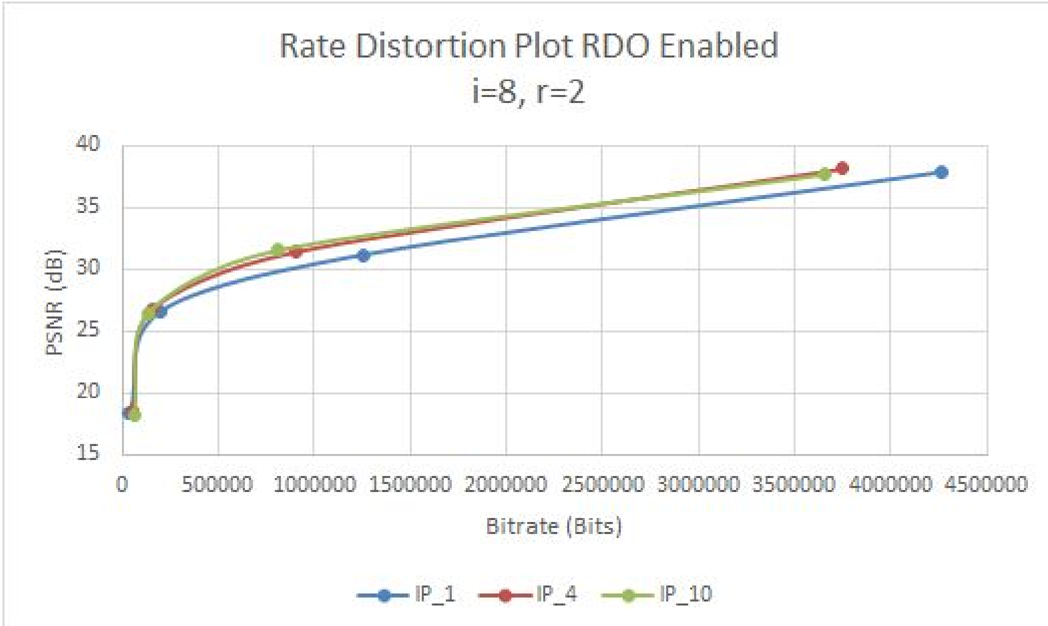

Figure 5: R-D plot for i = 16, range =2 with varying i_period, RDO enabled

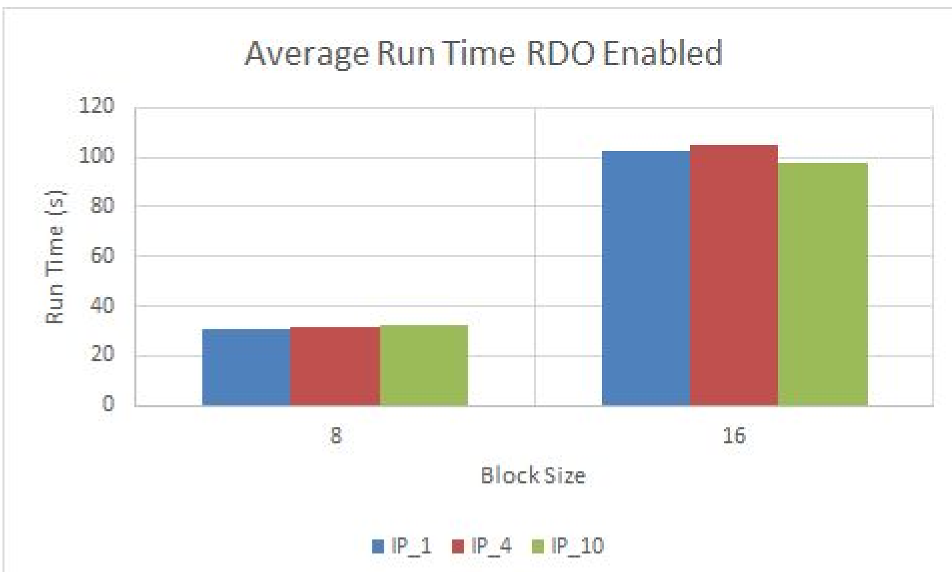

Figure 6: Run time for RDO enabled for different intra periods

1.1.3 Comparison

The following graphs will compare the quality (PSNR) vs bitrate (bits). Intra period of 1 is not shown since our RDO optimization was implemented in the Interframe Prediction function, and therefore will never be triggered in an intra only bitstream sequence. Data points for only QP>5 are shown since our RDO optimization only optimizes for a quantization parameter greater than 5.

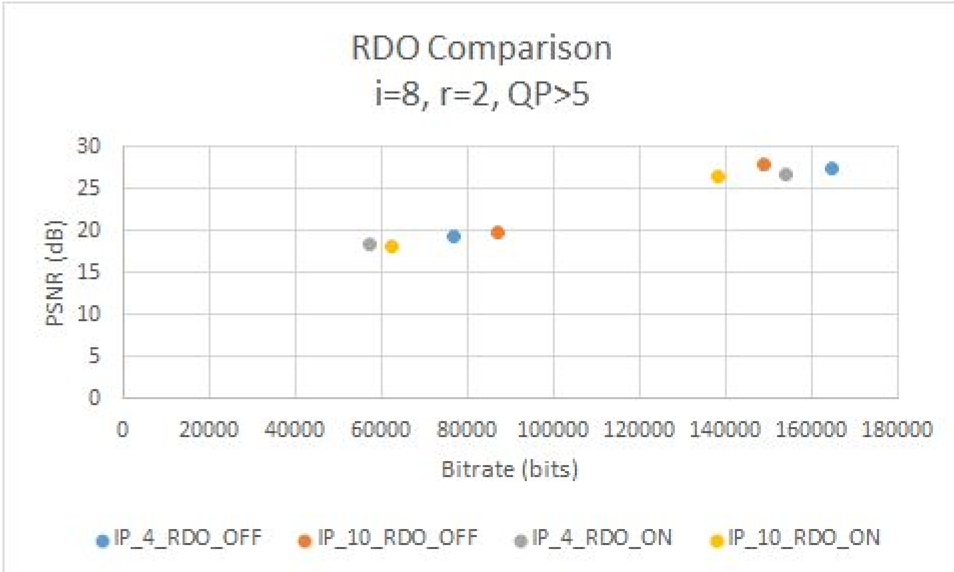

Figure 7: R-D plot comparison of RDO modes for i = 8, range = 2, for various intra periods.

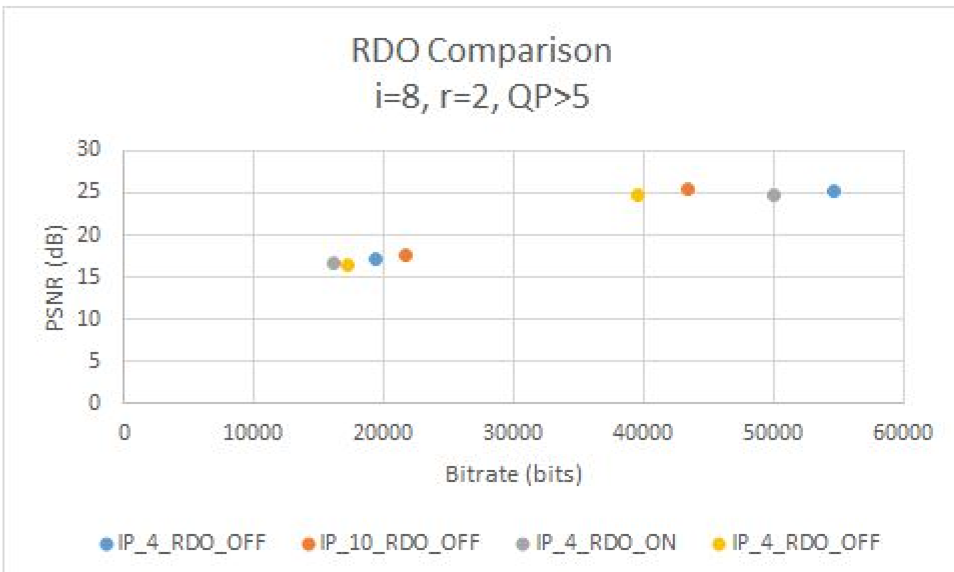

Figure 8: R-D plot comparison of RDO modes for i = 16, range =2, for various intra periods.

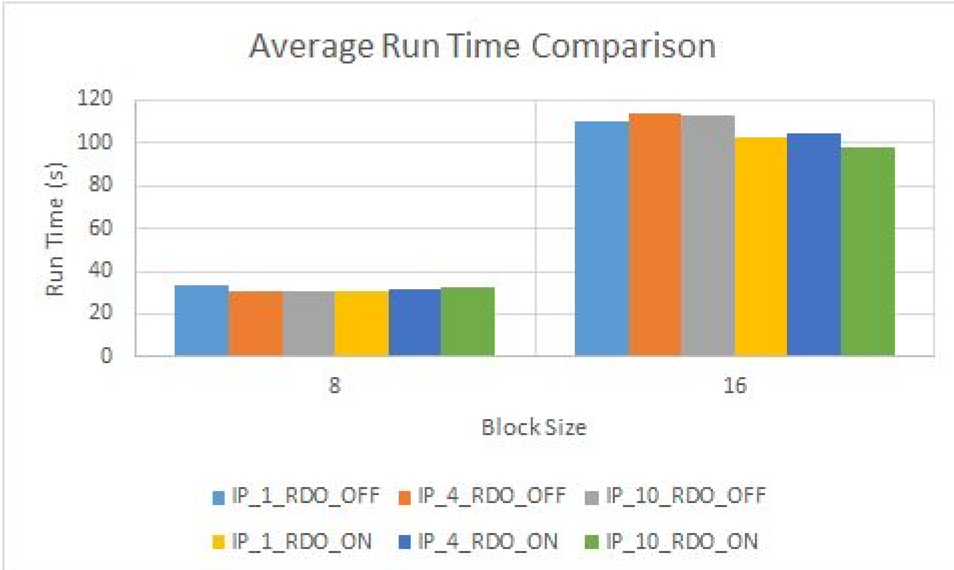

Figure 9: Runtime comparison for RDO modes for various intra periods

As it can be seen in the comparison of the RDO enabled vs disabled data points in Figures 8 and 9, the RDO optimization we implemented gave us the desired result. Both in block size 8 and 16, we were able to achieve a smaller number of bits for about the same quality. In terms of performance, the RDO optimization saved more time in the 16x16 motion estimation search since we skipped the search in most cases, in favour of encoding the previous motion vector.

1.2 BIts Per Frame Analysis

The following graphs will look at the bits per frames used to encode the I frames for different intra period, quantizations and RDO modes. The plots all use the first 10 frames of Foreman CIF. The x-axis are the frame index and the y-axis is the bits per frame. The following plots were generated with RDO disabled, using the default motion estimation algorithms.

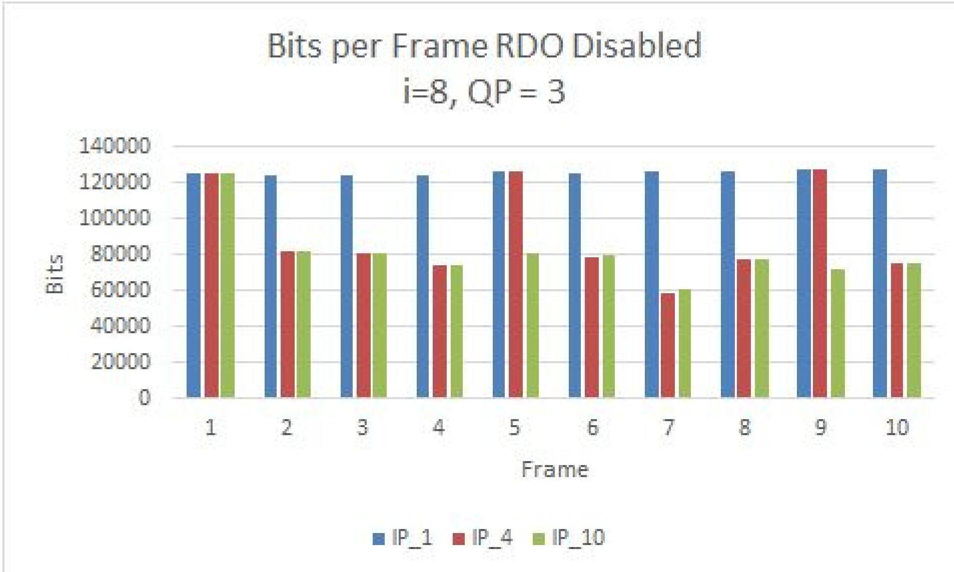

Figure 10: Bits per from for i=8, QP=3 for various Intra periods, RDO Disabled

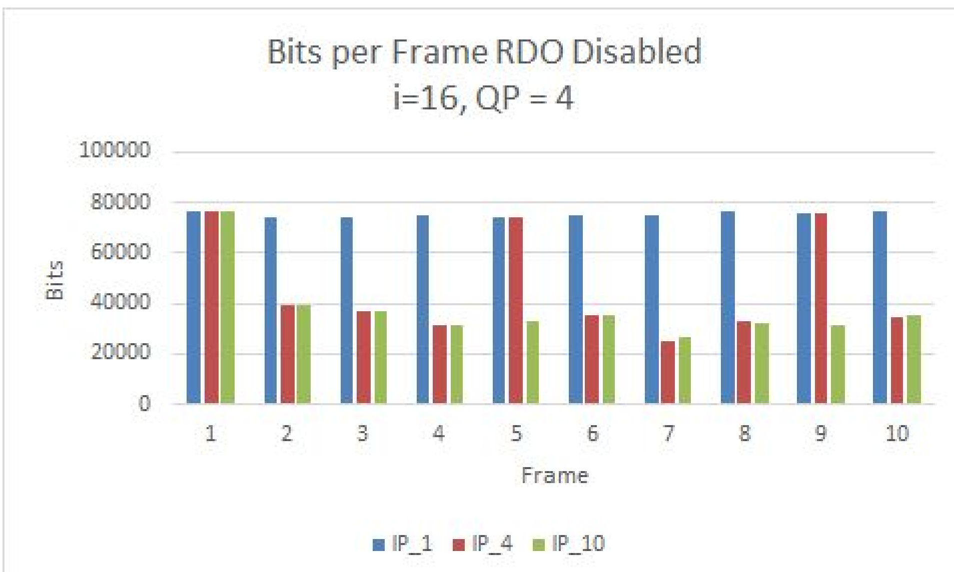

Figure 11: Bits per from for i=16, QP=4 for various Intra periods, RDO Disabled

1.3 Discussion

1. **Which kind of frames (Intra or Inter) typically consume more bitrate?**

Intra Frames consumed more bitrate than inter frames.

2. **Why?**

Because intra only relies on the special domain to find it's best prediction block. This means you will generate a larger residual coefficient to be encoded and require more bits to be encoded. Inter prediction will yield a better predictor. Inter prediction has more ways to search around several previous frames and find a match. Therefore finding a better match and generating lower residual values and less bit to be allocated for the residual coefficients.

3. **Is this true across the entire QP range?**

No this is true for low QP values. For large QP values your residual will be very small independently of your predictor.

4. **Would it make sense to RD-Optimize the frame type (try encoding a frame as Intra and as Inter and compare their RD_Costs)?**

Yes it would make sense however it would come as a cost of runtime since you would have to encode two frames.

5. **Any faster way we can try to select the frame type?**

Yes, what we could do is if the current frame to be encoded is a complete scene change we would encoded as a Intra frame. We would this since we know we wouldn't find a good Inter predictor in the previous frame. If the frame is not a scene change then we are better off using an Inter frame.

6. **For (i=8, search range = 2, and QP=3), what is the compression ratio of the 10 frames of Foreman CIF compared to the uncompressed Y component? What is the average PSNR?**

Frame	Coeff Bits	MDiff Bits	Bits per Frame	PSNR (dB)
1	121766	3020	124786	31.1872
2	121437	2958	124395	31.12059
3	121037	2946	123983	31.19817
4	120974	2992	123966	31.2548
5	123026	2922	125948	30.71621
6	122121	2962	125083	31.30356
7	122870	2992	125862	31.29067
8	123313	2902	126215	31.05855
9	124344	2962	127306	31.62961

10	124219	2918	127137	31.15145

Table 1: Experiment data for i=8, r=2, QP=3 for first 10 frames of Foreman CIF

10 CIF Frames Size (352x288*10)	1,013760
10 CIF Frames Encoded	1,245681
Compression Ratio	0.814
Average PSNR	31.19

Table 2: Analysis of experiment data for i=8, r=2, QP=3 for first 10 frames of Foreman CIF

Exercise 2

2.1 Better Encoding Techniques

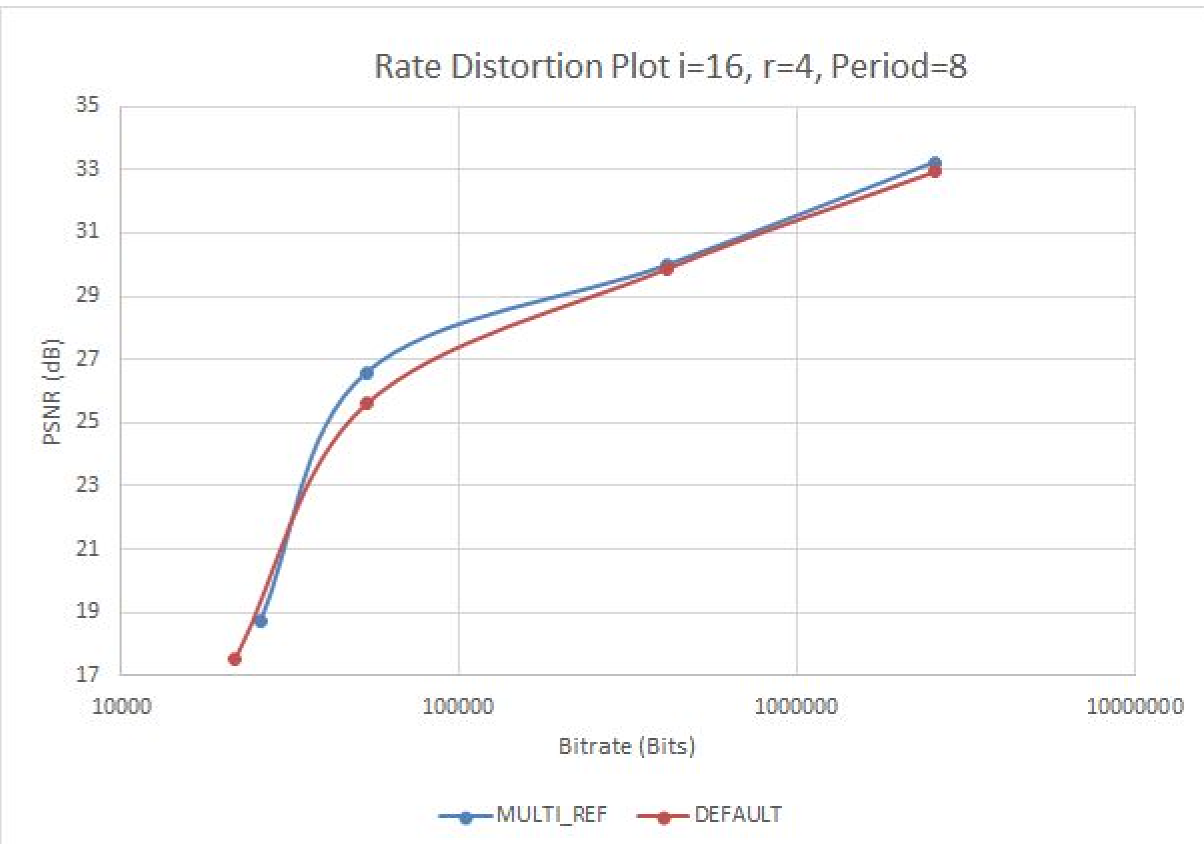

Figure 12: R-D plots for i=16, r=4, i_period= 8 for the first 10 Frames of foreman for different encoding algorithm optimizations.

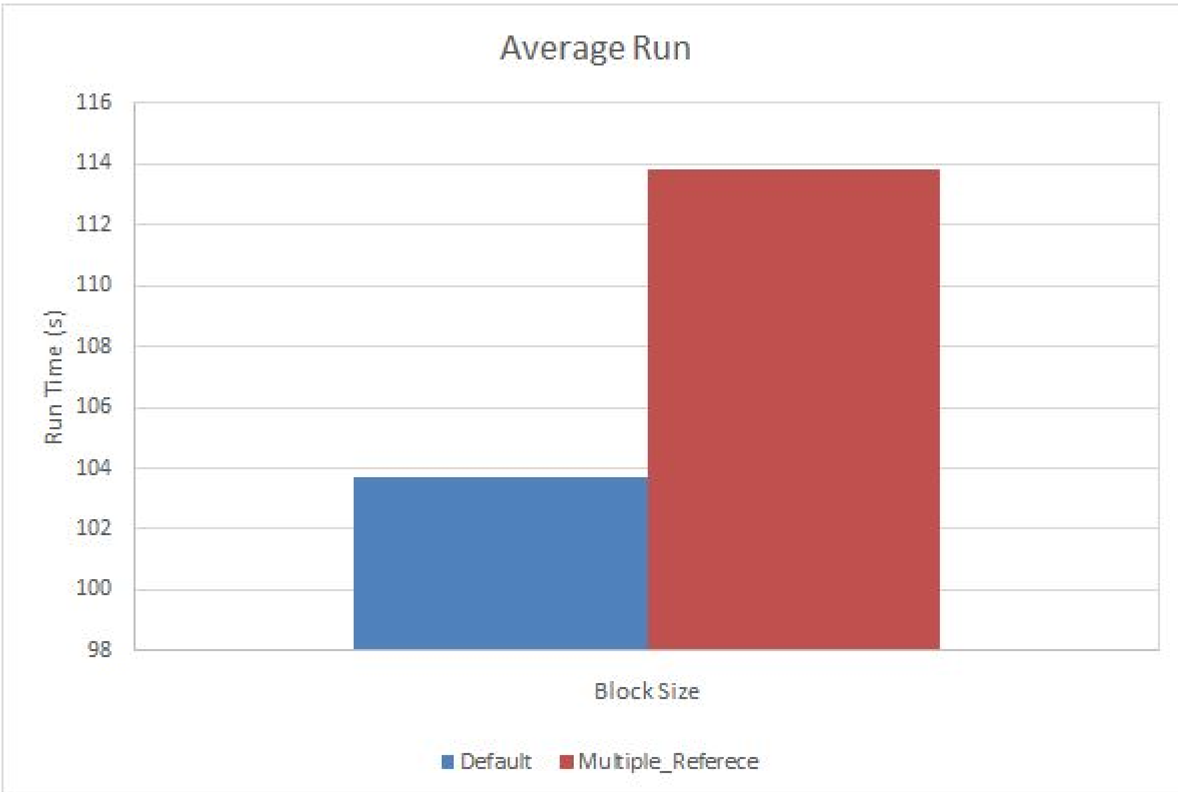

Figure 13: Execution time of different encoding algorithms

2.2 Discussion

1. **What effect do Multiple Reference Frames and Variable Block Size have on encoding speed and quality?**

It slows down the encoding speed since there are more computation involved and decisions to make. However the quality of the picture increases since we have more frames for which we can find a better predictor and smaller blocks to keep preserve smaller details in the picture.

2. **How do they compare to using a smaller block size and/or a larger search range?**

Variable block size would take longer time than smaller block size since you are breaking down your bigger blocks into smaller ones and taking extra processing time. Multi Reference frame vs large search range could take about the same time but it depends on how big your search Range is. For example if your multi reference frame R=1 and your larger search R=8, they could take the same amount of time.

3. **Could the effect of Multiple Reference Frames depend on content type?**

Yes it does if you have a lot of scene changes then you lower the chances of finding good predictors between frames.

4. **Can you think about what kind of video could benefit the most from it?**

Videos that have a lot of motions but no scene changes. For example a car moving down a road or a plane flying over a sky.

5. **For Variable Block Size, what kind of areas get larger block sizes in Intra frames?**

Areas that don’t have large variation would get a larger block size. You don’t need smaller blocks size to preserve the quality of it and would incur more bits. For example a background that is of the same colour would use a large block size as opposed to an area like grass where there are fine details would use a smaller block to keep the details.

6. **Are they the same in Inter frames? Why?**

Unlike intra frames, which have pixels with similar values in their neighborhood, inter frames can be coded with large block sizes if two blocks are similar. For example, in a video in which the background is still, and only an object is moving, the background could be encoded using large block sizes since there are more groups of pixels that correlate between each other between the two frames. Smaller blocks would be used on the object that is moving between frames.