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# Performance Report of Motion Vector Field Adaptive Search Technique (MVFAST)

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**Abstract**: *Motion Vector Field Adaptive Search Technique (MVFAST) [1,2] for fast motion estimation was presented in December 1999 at the MPEG meeting held in Maui, Hawaii. The proposed motion vector field adaptive search technique (MVFAST) effectively utilizes the information on correlation of motion vectors [3] of adjacent blocks for efficient motion estimation. In MVFAST, the motion activity at the current block position is first determined using the distribution of motion vectors of adjacent blocks. The motion activity is categorized as low, medium or high motion. The selection of search center and search strategy is adaptive to the motion activity. MVFAST adaptively exploits the two diamond-shaped search patterns employed by Diamond Search (DS) algorithm [4,5,6,7], which is available in the VM software [8,9]. The two search patterns of DS are effectively utilized based on the local motion activity to achieve significantly higher performance as compared to DS. The high performance of MVFAST was demonstrated at Maui through simulations, using 30 test cases specified by Video group. In Maui meeting, ISG specified 24 more test cases to study the robustness of fast motion estimation algorithms. In this document, we present the simulation results of MVFAST for all the 54 test cases jointly recommended by ISG and Video Group.*

## 1. Technical Description of MVFAST

In MPEG-4, the two components (i.e., horizontal and vertical coordinates) of the motion vector of each MB are coded differentially with respect to the corresponding components of the *predicted vector*. The predicted vector is the median of the three spatial neighborhood motion vectors that are already determined. In MVFAST, we make use of the distribution of the same three neighborhood motion vectors for the dual purposes-increasing the search speed and reducing the bits needed to code the motion vector.

### 1.1 Detection of stationary blocks

A large number of MBs in the video sequences (e.g., *talking head* video sequences) with low-motion content, have motion vectors equal to (0,0). Such MBs in the regions of no-motion activity can be detected simply based on the SAD at the origin. Therefore, we suggest a phase, called *early elimination of search*, as the first step in motion estimation as follows. The search is terminated immediately when the SAD for a MB obtained at (0,0) is less than a threshold $T$, and the motion vector is assigned as (0,0). Through extensive simulations, we found that among those zero-motion blocks identified, about 98% of them have SAD at position (0,0) less than 512. Hence, we choose $T$=512 and enable the early elimination of search. The early elimination of search can be disabled by making T=0.

## 1.2 Determination of local motion activity

The *local motion vector field* at a MB position is defined as the set of motion vectors in the region of support (ROS) of that MB. The ROS of a MB includes the neighborhood MBs. In MVFAST, the ROS is shown in Fig. 1. Let $V=\{V_0, V_1, V_2, V_3\}$, where $V_0=(0,0)$ and, $V_i$ is the motion vector of $MB_i$ in the ROS for $i>0$ (see Fig. 2). The cityblock length of $V_i=(x_i,y_i)$ is defined as $l_{vi}=|x_i|+|y_i|$. Let $L = \underset{v_i}{MAX}(l_{v_i})$ . The motion activity at the current MB position is defined as follows.

Motion Activity = Low if $L \leq L_1$
= Medium ; if $L_1 < L \leq L_2$
= High ; if $L > L_2$ ; …(1)

where, $L_1$ and $L_2$ are integer constants. We choose $L_1$ and $L_2$ as the cityblock distance from the center point of the pattern to any other point on the small and large search patterns (see Fig. 3), respectively. Thus $L_1=1$ and $L_2=2$.

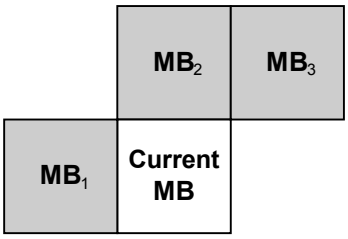


Fig. 1: Region of support for the current MB consists of $MB_1$, $MB_2$ and $MB_3$.

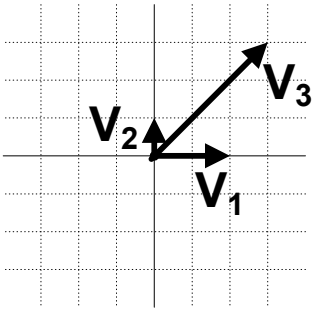


Fig. 2: Example of distribution of vectors belonging to set $V$. In this case, $l_{v1}=2$, $l_{v2}=1$, $l_{v3}=6$; thus $L=MAX\{l_{v1}, l_{v2}, l_{v3}\}= 6$.

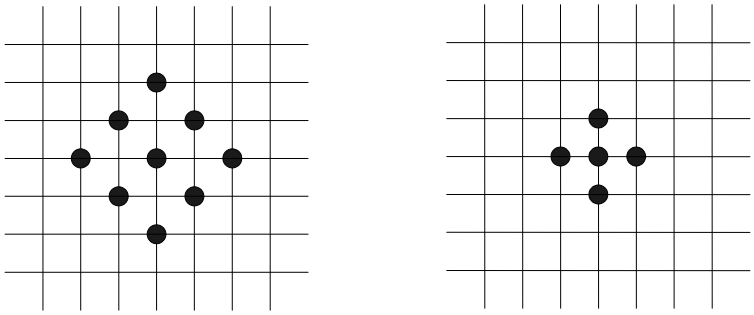

Fig. 3: Search Patterns - (a) Large Diamond Search Pattern (LDSP), (b) Small Diamond Search Pattern (SDSP).

### 1.3 Selection of search center

The choice of the search center depends on the local motion activity at the current MB position. If the motion activity is low or medium, the search center is the origin. Otherwise, the vector belonging to set V that yields the minimum sum of absolute difference (SAD) is chosen as the search center.

### 1.4 Local search

A local search is performed around the search center to obtain the motion vector for the current MB. The search patterns employed for the local search are shown in Fig. 3. Two strategies are proposed for the local search and their choice depends on the motion activity identified. If the motion activity is low or high, we employ small diamond search (SDS). Otherwise, we choose large diamond search (LDS).

#### i) *Small diamond search* (SDS):

**Step 1**: Small diamond search pattern (SDSP) is centered at the search center, and all the checking points of SDSP are tested. If the center position yields the minimum SAD (i.e., no motion), then the center represents the motion vector; otherwise, go to Step 2.

**Step 2**: The center of SDSP moves to the point where the minimum SAD was obtained in the previous step, and all the points on SDSP are tested. If the center position yields the minimum SAD, then the center represents the motion vector; otherwise, recursively repeat this step.

#### *ii) Large diamond search* (LDS*):*

**Step 1**: Large diamond search pattern (LDSP) is centered at the search center, and all the checking points of LDSP are tested. If the center position gives the minimum SAD, go to Step 3; otherwise, go to Step 2.

**Step 2**: The center of LDSP moves to the point where the minimum SAD was obtained in the previous step, and all the points on LDSP are tested. If the center position gives the minimum SAD, go to Step 3; otherwise, recursively repeat this step.

**Step 3**: Switch the search pattern from LDSP to SDSP. The point that yields the minimum SAD, is the final solution of the motion vector.

Table 1 summarizes the methodology for selection of search center and search strategy depending on the motion activity at the current MB position.

| Motion Activity | Search Center | Local Search Strategy |
|---|---|---|
| Low | Origin | SDS |
| Medium | Origin | LDS |
| High | The position of the vector in set *V* that yields minimum SAD | SDS |

Table 1: The decision table for MVFAST

### 1.5 Attractive Features of MVFAST

1) Simplicity: The software code of MVFAST is obtained by adding a few lines of supplementary code to diamond search, which is currently available in VM reference software.

2) Stability: MVFAST is well tested, as MVFAST is a more generalized and more intelligent version of the Diamond Search with the addition of few lines of supplementary code. Moreover, Diamond Search is already tested for more than two years since the beginning of its core experiments and about 8 months after its integration into VM software. Therefore, the high stability of MVFAST is assured.

3) Cost-effectiveness: MVFAST is a cost-effective solution to fast motion estimation. MVFAST is implemented in an intelligent way such that the overlap of search points is minimized when the search pattern moves [8, 9]. Thus, it does not require any extra memory to keep a record of search points visited. In addition, it does not require extra memory to store the motion vectors.

4) Scalability: The MVFAST algorithm explained above can be considered as the main profile of MVFAST. The low, medium and high motion activity cases in Table-1, can be considered individually as three other different profiles of MVFAST. Depending on the video coding applications, any one of these individual profiles can be turned "ON" simply by adjusting the two parameters, $L_1$ and $L_2$ , in Equation-1. If we set $L_1 = L_2$ = Search Range, we obtain "low motion activity" profile. The "medium motion activity" profile ( which is the same as Diamond Search ) can be obtained if we set $L_1$ =-1 and $L_2$ = Search Range. For "high motion activity" profile, we can set $L_1 = L_2$ = -1.

5) High Performance: As compared to other fast motion estimation algorithms, MVFAST is much faster. Despite its high-speed performance, the subjective video quality obtained with MVFAST is almost the same as that obtained with Full Search.

6) Robustness: MVFAST was first presented to MPEG in December 1999 and its high performance is proved based on 30 test cases specified by the Video Group. Afterwards, ISG further recommended additional 24 test cases for testing robustness using CCIR size video sequences. It is shown that MVFAST maintains its high performance in terms of both search speed and subjective quality for these extra 24 cases.

## 2. Test Conditions (N3141):

a) VM Software : MoMuSys-V2.0.2-990809
b) No. of frames in the original video sequence = 300
c) "No frame skipping flag" **Set**
d) Overlapped Motion compensation **Off**
e) Error resilience **Off**
f) Interlace **Off**
g) Rounding Control **On**
h) Unrestricted Motion Vectors **On**
i) Half-pixel accuracy **Enabled**
j) Advanced Prediction **Off**
k) Rate control is used for both low bit rate and high bit rate tests. For the low bit rate, the VM5 frame level rate control and encoding format (IPPP….) is used. For the high bit rate, TM5 rate control with (N,M) = (15,1) is used.
l) Quantization matrix (intra/non-intra) is set to MPEG4 – VM7 for low bit rates and MPEG2 – TM5 for high bit rates.
m) Group of VOPs PERIOD is set to **0 (No GOV)**.

## 3. Results

Tests are carried out for various bit rates and frame rates combinations as specified in N3141. All the tests are conducted on SUN Ultra-450 workstation. APPENDIX-A provides the comparison of PSNR and number of search points for Full Search (FS) and MVFAST. APPENIX-B shows the 10 worst case PSNR values of MVFAST as compared to full search for each of the 54 test cases. The graphs of number of search points and PSNR-Y for each frame for the four sub-sampled sequences are provided as specified in N3141.

## 4. Discussions:

Although MVFAST is implemented in an intelligent way such that the overlap of search points is minimized when the search pattern moves [8,9], some search points are visited more than once in the following cases: (a) when search pattern makes a right-angle turn, (b) if two or more vectors in set V (see section 1.2) are same. This overlap can be avoided by keeping the record of all the search points visited and testing if the current search point is visited earlier. Thus further improvement over speed-up can be achieved.

The search point (0,0) is always tested in MVFAST. However, some improvement in computational gain is obtained by testing (0,0) point only if any of the motion vectors in the ROS have motion vector=(0,0).

Through extensive experiments conducted by us, it is found that further improvement in objective quality can be achieved for CCIR sequences with high global motion by including the motion vector of collocated block in the previously coded non-intra frame in the set V (see section 1.2). The results of MVFAST with the above mentioned schemes for improvement of speed-up (or computational gain) and objective quality for the "high motion activity profile" are given in Appendix-D. During the motion estimation of interlaced pictures, each frame prediction of macroblock motion is performed before field motion estimation. Therefore, for field motion estimation of current macroblock, its frame motion vector is included in set *V*.

From hardware implementation viewpoint, to restrict the total number of search points for a block in the worst case to be *N*, an additional stopping criterion, - "stop the search when the number of search points visited so far is equal to *N*" – can be included in SDS and LDS given in section 1.4.

## 5. Conclusions

MVFAST is a stable and well-tested technology. In addition, MVFAST possesses other attractive features such as simplicity, scalability and cost effectiveness. Extensive simulation results have demonstrated the high performance of MVFAST.

## *References:*

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[3] Prabhudev I. Hosur and Kai-Kuang Ma, "Fast Block Motion Estimation Based on Prediction of Initial Motion Vectors of Interleaved Blocks using Spatial Correlation," Fourth Asia-Pacific Conference on Communications / Sixth Singapore International Conference on Communication Systems, November 23-27, 1998.

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*[6]* Kai-Kuang Ma and P. I. Hosur*, "Core Experiment Results of Fast Motion Estimation Based on New Test conditions (Q4a)," ISO/IEC JTC1/SC29/WG11 M4934, Vancouver, July 1999.*

[7] ISO/IEC JTC1/SC29/WG11 N2932, "MPEG-4 Video Verification Model version 14.0," pp. 301-303, October 1999.

[8] MoMuSys-V2.0.2-990809, ftp.tnt.uni-hannover.de

[9] Microsoft-V2cd-v02-990812, ftp.tnt.uni-hannover.de

# APPENDIX - A

## Comparison of average psnr values and search points of Full Search and MVFAST

| Sequence | Bitrate (kbps) | Frame Rate (fps) | Search Range | PSNR-Y | | PSNR-U | | PSNR-V | | SEARCH POINTS | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | FS | MVFAST | FS | MVFAST | FS | MVFAST | FS | MVFAST |
| container | 10 | 7.5 | 16 | 29.81 | 29.78 | 37.54 | 37.50 | 36.60 | 36.64 | 7501824 | 33149 |
| container | 10 | 7.5 | 32 | 29.72 | 29.79 | 37.55 | 37.49 | 36.57 | 36.59 | 27142090 | 33486 |
| Hall monitor | 10 | 7.5 | 16 | 30.35 | 30.32 | 36.38 | 36.28 | 39.57 | 39.51 | 7501824 | 31418 |
| Hall monitor | 10 | 7.5 | 32 | 30.29 | 30.23 | 36.24 | 36.46 | 39.49 | 39.63 | 27142090 | 31370 |
| Mother Dtr | 24 | 10 | 16 | 34.80 | 34.76 | 40.23 | 40.24 | 41.02 | 40.98 | 10036224 | 48611 |
| Mother Dtr | 24 | 10 | 32 | 34.81 | 34.68 | 40.28 | 40.27 | 40.98 | 41.02 | 36311715 | 49604 |
| Silence | 24 | 10 | 16 | 30.85 | 30.88 | 35.56 | 35.68 | 36.93 | 36.95 | 10036224 | 71268 |
| Silence | 24 | 10 | 32 | 30.78 | 30.88 | 35.42 | 35.69 | 36.90 | 37.05 | 36311715 | 71506 |
| Coastguard | 48 | 10 | 16 | 28.88 | 28.83 | 40.14 | 40.20 | 42.07 | 42.15 | 10036224 | 99468 |
| Coastguard | 48 | 10 | 32 | 28.90 | 28.82 | 40.02 | 40.20 | 41.88 | 42.10 | 36311715 | 99977 |
| News | 48 | 7.5 | 16 | 31.84 | 31.80 | 35.72 | 36.06 | 37.31 | 37.49 | 30007296 | 168005 |
| News | 48 | 7.5 | 32 | 31.90 | 31.75 | 35.79 | 35.93 | 37.35 | 37.46 | 114227658 | 171416 |
| News | 112 | 15 | 16 | 34.05 | 33.97 | 38.04 | 37.93 | 38.93 | 38.91 | 60420096 | 264061 |
| News | 112 | 15 | 32 | 34.03 | 33.96 | 37.93 | 37.95 | 38.85 | 38.85 | 229998933 | 266329 |
| Foreman | 112 | 10 | 16 | 30.04 | 29.91 | 36.78 | 36.93 | 37.53 | 37.70 | 40144896 | 474898 |
| Foreman | 112 | 10 | 32 | 30.37 | 30.18 | 36.88 | 36.96 | 37.56 | 37.81 | 152818083 | 497026 |
| Coastguard | 112 | 10 | 16 | 27.03 | 27.05 | 38.87 | 39.12 | 41.65 | 41.64 | 40144896 | 413640 |
| Coastguard | 112 | 10 | 32 | 27.06 | 27.10 | 38.64 | 39.08 | 40.99 | 40.99 | 152818083 | 413316 |
| Foreman | 512 | 15 | 16 | 34.51 | 34.43 | 40.25 | 40.21 | 41.47 | 41.45 | 56770560 | 580020 |
| Foreman | 512 | 15 | 32 | 34.84 | 34.70 | 40.56 | 40.45 | 41.75 | 41.69 | 216106380 | 589759 |
| Foreman | 512 | 15 | 48 | 34.88 | 34.72 | 40.62 | 40.48 | 41.79 | 41.72 | 461637680 | 591276 |
| Foreman | 1024 | 30 | 16 | 35.47 | 35.37 | 41.05 | 40.96 | 42.36 | 42.29 | 113541120 | 902601 |
| Foreman | 1024 | 30 | 32 | 35.53 | 35.41 | 41.13 | 41.01 | 42.43 | 42.34 | 432212760 | 911217 |
| Foreman | 1024 | 30 | 48 | 35.51 | 35.40 | 41.11 | 41.00 | 42.40 | 42.32 | 923275360 | 911377 |
| Tennis | 1024 | 30 | 16 | 34.98 | 34.92 | 41.89 | 41.81 | 41.01 | 40.93 | 94617600 | 519726 |
| Tennis | 1024 | 30 | 32 | 35.00 | 34.92 | 41.91 | 41.81 | 41.02 | 40.93 | 358185240 | 522012 |
| Tennis | 1024 | 30 | 48 | 34.97 | 34.92 | 41.88 | 41.82 | 41.01 | 40.93 | 760543840 | 521379 |
| Tennis | 2048 | 30 | 16 | 37.95 | 37.90 | 43.47 | 43.41 | 42.98 | 42.93 | 94617600 | 480644 |
| Tennis | 2048 | 30 | 32 | 37.95 | 37.90 | 43.47 | 43.42 | 42.97 | 42.92 | 358185240 | 482591 |
| Tennis | 2048 | 30 | 48 | 37.94 | 37.89 | 43.45 | 43.40 | 42.96 | 42.91 | 760543840 | 483244 |

| Sequence | Bitrate (kbps) | Frame Rate (fps) | Search Range | PSNR-Y | | PSNR-U | | PSNR-V | | SEARCH POINTS | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | FS | MVFAST | FS | MVFAST | FS | MVFAST | FS | MVFAST |
| Bus | 4000 | 30 | 64 | 29.78 | 29.10 | 37.53 | 37.35 | 39.73 | 39.49 | 2827221219 | 1855093 |
| Bus | 4000 | 30 | 128 | 29.78 | 29.09 | 37.50 | 37.36 | 39.69 | 39.49 | 10035121819 | 1855500 |
| Bus | 9000 | 30 | 64 | 34.03 | 33.45 | 39.18 | 39.05 | 41.65 | 41.46 | 2827221219 | 1800419 |
| Bus | 9000 | 30 | 128 | 34.03 | 33.45 | 39.17 | 39.05 | 41.64 | 41.45 | 10035121819 | 1798894 |
| Basket Ball | 4000 | 30 | 64 | 26.71 | 26.40 | 33.37 | 33.39 | 33.32 | 33.32 | 5580207144 | 4208477 |
| Basket Ball | 4000 | 30 | 128 | 26.67 | 26.36 | 33.33 | 33.37 | 33.29 | 33.30 | 20043089232 | 4220679 |
| Basket Ball | 9000 | 30 | 64 | 30.78 | 30.46 | 35.74 | 35.70 | 35.60 | 35.55 | 5580207144 | 4086493 |
| Basket Ball | 9000 | 30 | 128 | 30.76 | 30.44 | 35.72 | 35.69 | 35.59 | 35.53 | 20043089232 | 4095415 |
| Cheerleader | 4000 | 30 | 64 | 29.27 | 29.16 | 31.68 | 31.75 | 32.72 | 32.86 | 2827221219 | 1948575 |
| Cheerleader | 4000 | 30 | 128 | 29.25 | 29.13 | 31.66 | 31.73 | 32.69 | 32.83 | 10035121819 | 1949110 |
| Cheerleader | 9000 | 30 | 64 | 33.65 | 33.66 | 35.24 | 35.35 | 36.08 | 36.23 | 2827221219 | 1856979 |
| Cheerleader | 9000 | 30 | 128 | 33.64 | 33.65 | 35.24 | 35.33 | 36.08 | 36.22 | 10035121819 | 1859436 |
| Stefan | 4000 | 30 | 64 | 30.77 | 30.02 | 36.29 | 36.04 | 36.25 | 35.98 | 5695121880 | 3252715 |
| Stefan | 4000 | 30 | 128 | 30.77 | 30.03 | 36.28 | 36.05 | 36.23 | 35.98 | 20214633880 | 3255005 |
| Stefan | 9000 | 30 | 64 | 34.97 | 34.43 | 38.99 | 38.66 | 39.09 | 38.75 | 5695121880 | 3140881 |
| Stefan | 9000 | 30 | 128 | 34.97 | 34.43 | 38.99 | 38.66 | 39.09 | 38.75 | 20214633880 | 3143786 |
| Flower | 4000 | 30 | 64 | 28.33 | 28.13 | 32.08 | 31.99 | 33.99 | 33.95 | 2827221219 | 1987167 |
| Flower Gdn. | 4000 | 30 | 128 | 28.31 | 28.10 | 32.06 | 31.97 | 33.98 | 33.94 | 10035121819 | 1985856 |
| Flower Gdn. | 9000 | 30 | 64 | 33.17 | 32.99 | 35.47 | 35.39 | 36.38 | 36.33 | 2827221219 | 1982671 |
| Flower Gdn. | 9000 | 30 | 128 | 33.16 | 32.98 | 35.46 | 35.38 | 36.38 | 36.32 | 10035121819 | 1982640 |
| Bus Subs. 3:1 | 12000 | 30 | 128 | 34.74 | 33.60 | 39.20 | 38.92 | 41.64 | 41.29 | 3248780445 | 691457 |
| Basket Subs. 3:1 | 12000 | 30 | 128 | 30.71 | 30.52 | 35.63 | 35.83 | 35.50 | 35.66 | 6652232125 | 1626169 |
| Stefan Subs. 3:1 | 12000 | 30 | 128 | 35.20 | 34.77 | 39.02 | 38.92 | 39.03 | 38.92 | 6714146253 | 1408413 |
| Flower Subs. 3:1 | 12000 | 30 | 128 | 32.22 | 31.83 | 34.34 | 34.14 | 35.51 | 35.37 | 3248780445 | 581555 |

| Sequence | Bitrate (kbps) | Frame Rate (fps) | Search Range | $\delta_{PSNR-Y}$ | $\delta_{PSNR-U}$ | $\delta_{PSNR-V}$ | COMPUTATIONAL GAIN |
|---|---|---|---|---|---|---|---|
| container | 10 | 7.5 | 16 | -0.03 | -0.04 | 0.04 | 226 |
| container | 10 | 7.5 | 32 | 0.07 | -0.06 | 0.02 | 811 |
| Hall monitor | 10 | 7.5 | 16 | -0.03 | -0.10 | -0.06 | 239 |
| Hall monitor | 10 | 7.5 | 32 | -0.06 | 0.22 | 0.14 | 865 |
| Mother Dtr | 24 | 10 | 16 | -0.04 | 0.01 | -0.04 | 206 |
| Mother Dtr | 24 | 10 | 32 | -0.13 | -0.01 | 0.04 | 732 |
| Silence | 24 | 10 | 16 | 0.03 | 0.12 | 0.02 | 141 |
| Silence | 24 | 10 | 32 | 0.10 | 0.27 | 0.15 | 508 |
| Coastguard | 48 | 10 | 16 | -0.05 | 0.06 | 0.08 | 101 |
| Coastguard | 48 | 10 | 32 | -0.08 | 0.18 | 0.22 | 363 |
| News | 48 | 7.5 | 16 | -0.04 | 0.34 | 0.18 | 179 |
| News | 48 | 7.5 | 32 | -0.15 | 0.14 | 0.11 | 666 |
| News | 112 | 15 | 16 | -0.08 | -0.11 | -0.02 | 229 |
| News | 112 | 15 | 32 | -0.07 | 0.02 | 0.00 | 864 |
| Foreman | 112 | 10 | 16 | -0.13 | 0.15 | 0.17 | 85 |
| Foreman | 112 | 10 | 32 | -0.19 | 0.08 | 0.25 | 307 |
| Coastguard | 112 | 10 | 16 | 0.02 | 0.25 | -0.01 | 97 |
| Coastguard | 112 | 10 | 32 | 0.04 | 0.44 | 0.00 | 370 |
| Foreman | 512 | 15 | 16 | -0.08 | -0.04 | -0.02 | 98 |
| Foreman | 512 | 15 | 32 | -0.14 | -0.11 | -0.06 | 366 |
| Foreman | 512 | 15 | 48 | -0.16 | -0.14 | -0.07 | 781 |
| Foreman | 1024 | 30 | 16 | -0.10 | -0.09 | -0.07 | 126 |
| Foreman | 1024 | 30 | 32 | -0.12 | -0.12 | -0.09 | 474 |
| Foreman | 1024 | 30 | 48 | -0.11 | -0.11 | -0.08 | 1013 |
| Tennis | 1024 | 30 | 16 | -0.06 | -0.08 | -0.08 | 182 |
| Tennis | 1024 | 30 | 32 | -0.08 | -0.10 | -0.09 | 686 |
| Tennis | 1024 | 30 | 48 | -0.05 | -0.06 | -0.08 | 1459 |
| Tennis | 2048 | 30 | 16 | -0.05 | -0.06 | -0.05 | 197 |
| Tennis | 2048 | 30 | 32 | -0.05 | -0.05 | -0.05 | 742 |
| Tennis | 2048 | 30 | 48 | -0.05 | -0.05 | -0.05 | 1574 |

| Sequence | Bitrate (kbps) | Frame Rate (fps) | Search Range | $\delta_{PSNR-Y}$ | $\delta_{PSNR-U}$ | $\delta_{PSNR-V}$ | COMPUTATIONAL GAIN |
|---|---|---|---|---|---|---|---|
| Bus | 4000 | 30 | 64 | -0.68 | -0.18 | -0.24 | 1524 |
| Bus | 4000 | 30 | 128 | -0.69 | -0.14 | -0.20 | 5408 |
| Bus | 9000 | 30 | 64 | -0.58 | -0.13 | -0.19 | 1570 |
| Bus | 9000 | 30 | 128 | -0.58 | -0.12 | -0.19 | 5578 |
| Basket Ball | 4000 | 30 | 64 | -0.31 | 0.02 | 0.00 | 1326 |
| Basket Ball | 4000 | 30 | 128 | -0.31 | 0.04 | 0.01 | 4749 |
| Basket Ball | 9000 | 30 | 64 | -0.32 | -0.04 | -0.05 | 1366 |
| Basket Ball | 9000 | 30 | 128 | -0.32 | -0.03 | -0.06 | 4894 |
| Cheerleader | 4000 | 30 | 64 | -0.11 | 0.07 | 0.14 | 1451 |
| Cheerleader | 4000 | 30 | 128 | -0.12 | 0.07 | 0.14 | 5149 |
| Cheerleader | 9000 | 30 | 64 | 0.01 | 0.11 | 0.15 | 1522 |
| Cheerleader | 9000 | 30 | 128 | 0.01 | 0.09 | 0.14 | 5397 |
| Stefan | 4000 | 30 | 64 | -0.75 | -0.25 | -0.27 | 1751 |
| Stefan | 4000 | 30 | 128 | -0.74 | -0.23 | -0.25 | 6210 |
| Stefan | 9000 | 30 | 64 | -0.54 | -0.33 | -0.34 | 1813 |
| Stefan | 9000 | 30 | 128 | -0.54 | -0.33 | -0.34 | 6430 |
| Flower Gdn. | 4000 | 30 | 64 | -0.20 | -0.09 | -0.04 | 1423 |
| Flower Gdn. | 4000 | 30 | 128 | -0.21 | -0.09 | -0.04 | 5053 |
| Flower Gdn. | 9000 | 30 | 64 | -0.18 | -0.08 | -0.05 | 1426 |
| Flower Gdn. | 9000 | 30 | 128 | -0.18 | -0.08 | -0.06 | 5061 |
| Bus Subs. 3:1 | 12000 | 30 | 128 | -1.14 | -0.28 | -0.35 | 4698 |
| Basket Subs. 3:1 | 12000 | 30 | 128 | -0.19 | 0.20 | 0.16 | 4091 |
| Stefan Subs. 3:1 | 12000 | 30 | 128 | -0.43 | -0.10 | -0.11 | 4767 |
| Flower Subs. 3:1 | 12000 | 30 | 128 | -0.39 | -0.20 | -0.14 | 5586 |

$\delta_{PSNR-Y}$ = (PSNR_Y for MVFAST ) – (PSNR_Y for FS)
$\delta_{PSNR-U}$ = (PSNR_U for MVFAST) – (PSNR_U for FS)
$\delta_{PSNR-V}$ = (PSNR_V for MVFAST) – (PSNR_V for FS)

# APPENDIX B

## Worst 10 frame-wise psnr values for MVFAST with respect to Full Search

| Container (10kbps , 7.5 fps) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Search Range=16 | | | | Search Range=32 | | | | | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| | 30.70 | 29.78 | -0.93 | | 30.31 | 29.28 | -1.02 | | | | |
| | 29.86 | 29.21 | -0.65 | | 30.14 | 29.74 | -0.40 | | | | |
| | 29.53 | 28.87 | -0.65 | | 29.30 | 28.92 | -0.38 | | | | |
| | 29.73 | 29.10 | -0.63 | | 29.66 | 29.33 | -0.33 | | | | |
| | 30.43 | 29.81 | -0.62 | | 29.64 | 29.34 | -0.31 | | | | |
| | 29.50 | 28.90 | -0.60 | | 29.45 | 29.18 | -0.28 | | | | |
| | 29.67 | 29.14 | -0.53 | | 30.26 | 29.99 | -0.27 | | | | |
| | 29.24 | 28.74 | -0.50 | | 29.55 | 29.30 | -0.24 | | | | |
| | 29.70 | 29.21 | -0.49 | | 29.60 | 29.36 | -0.24 | | | | |
| | 30.38 | 29.94 | -0.45 | | 30.10 | 29.87 | -0.23 | | | | |
| Hall Monitor (10kbps , 7.5 fps) | | | | | | | | | | | |
| Search Range=16 | | | | Search Range=32 | | | | | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| | 30.71 | 29.81 | -0.90 | | 31.47 | 30.20 | -1.27 | | | | |
| | 30.27 | 29.61 | -0.66 | | 30.40 | 29.31 | -1.08 | | | | |
| | 29.97 | 29.47 | -0.50 | | 30.11 | 29.29 | -0.82 | | | | |
| | 30.50 | 30.02 | -0.48 | | 30.88 | 30.20 | -0.67 | | | | |
| | 30.52 | 30.06 | -0.46 | | 30.58 | 29.94 | -0.63 | | | | |
| | 30.19 | 29.83 | -0.37 | | 30.12 | 29.49 | -0.63 | | | | |
| | 30.70 | 30.38 | -0.32 | | 29.95 | 29.33 | -0.62 | | | | |
| | 30.64 | 30.33 | -0.31 | | 31.63 | 31.02 | -0.61 | | | | |
| | 30.24 | 29.99 | -0.25 | | 30.68 | 30.17 | -0.51 | | | | |
| | 30.15 | 29.91 | -0.25 | | 29.66 | 29.16 | -0.50 | | | | |
| Mother-Daughter (24kbps , 10fps) | | | | | | | | | | | |
| Search Range=16 | | | | Search Range=32 | | | | | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| | 33.82 | 33.44 | -0.39 | | 33.51 | 33.03 | -0.48 | | | | |
| | 34.14 | 33.76 | -0.37 | | 33.36 | 32.93 | -0.43 | | | | |
| | 33.52 | 33.15 | -0.37 | | 34.90 | 34.47 | -0.43 | | | | |
| | 33.84 | 33.50 | -0.34 | | 34.30 | 33.92 | -0.38 | | | | |
| | 34.32 | 34.01 | -0.31 | | 35.38 | 35.01 | -0.37 | | | | |
| | 33.61 | 33.32 | -0.29 | | 35.00 | 34.64 | -0.36 | | | | |
| | 35.30 | 35.06 | -0.24 | | 36.62 | 36.27 | -0.35 | | | | |
| | 34.48 | 34.24 | -0.24 | | 34.33 | 33.98 | -0.35 | | | | |
| | 34.34 | 34.12 | -0.22 | | 36.59 | 36.26 | -0.33 | | | | |
| | 36.66 | 36.44 | -0.22 | | 36.55 | 36.23 | -0.32 | | | | |

| Silent (24kbps , 10 fps) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Search Range=16 | | | | Search Range=32 | | | | | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| | 31.54 | 30.88 | -0.67 | | 31.46 | 30.87 | -0.59 | | | | |
| | 32.28 | 31.82 | -0.46 | | 30.84 | 30.41 | -0.43 | | | | |
| | 31.56 | 31.13 | -0.43 | | 32.14 | 31.83 | -0.31 | | | | |
| | 30.45 | 30.06 | -0.39 | | 30.75 | 30.48 | -0.27 | | | | |
| | 31.11 | 30.77 | -0.34 | | 31.24 | 31.00 | -0.24 | | | | |
| | 31.33 | 31.03 | -0.30 | | 30.89 | 30.70 | -0.19 | | | | |
| | 31.67 | 31.38 | -0.28 | | 29.88 | 29.73 | -0.16 | | | | |
| | 30.23 | 30.03 | -0.20 | | 30.08 | 29.92 | -0.15 | | | | |
| | 31.81 | 31.61 | -0.20 | | 31.11 | 30.95 | -0.15 | | | | |
| | 30.60 | 30.40 | -0.20 | | 30.90 | 30.75 | -0.15 | | | | |
| Coastguard(48kbps , 10 fps) | | | | | | | | | | | |
| Search Range=16 | | | | Search Range=32 | | | | | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| | 30.22 | 29.64 | -0.58 | | 30.31 | 29.54 | -0.78 | | | | |
| | 30.08 | 29.54 | -0.54 | | 30.24 | 29.68 | -0.56 | | | | |
| | 30.14 | 29.65 | -0.49 | | 29.28 | 28.91 | -0.37 | | | | |
| | 29.11 | 28.82 | -0.29 | | 29.95 | 29.58 | -0.37 | | | | |
| | 29.74 | 29.49 | -0.25 | | 29.63 | 29.30 | -0.33 | | | | |
| | 29.17 | 28.94 | -0.23 | | 29.63 | 29.31 | -0.32 | | | | |
| | 29.55 | 29.31 | -0.23 | | 29.11 | 28.80 | -0.31 | | | | |
| | 29.89 | 29.68 | -0.22 | | 30.04 | 29.73 | -0.30 | | | | |
| | 29.74 | 29.53 | -0.21 | | 29.53 | 29.26 | -0.26 | | | | |
| | 29.22 | 29.02 | -0.21 | | 29.74 | 29.49 | -0.24 | | | | |
| News (48kbps , 7.5fps) | | | | | | | | | | | |
| Search Range=16 | | | | Search Range=32 | | | | | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| | 32.78 | 31.77 | -1.01 | | 32.87 | 31.57 | -1.30 | | | | |
| | 32.31 | 31.52 | -0.79 | | 33.17 | 32.05 | -1.12 | | | | |
| | 32.87 | 32.20 | -0.67 | | 32.98 | 31.88 | -1.10 | | | | |
| | 32.29 | 31.75 | -0.53 | | 32.87 | 31.80 | -1.06 | | | | |
| | 31.91 | 31.38 | -0.52 | | 33.17 | 32.21 | -0.96 | | | | |
| | 31.89 | 31.48 | -0.40 | | 32.22 | 31.26 | -0.96 | | | | |
| | 32.27 | 31.89 | -0.38 | | 32.74 | 31.86 | -0.89 | | | | |
| | 31.87 | 31.52 | -0.35 | | 31.99 | 31.18 | -0.80 | | | | |
| | 31.88 | 31.55 | -0.33 | | 32.18 | 31.42 | -0.76 | | | | |
| | 33.73 | 33.45 | -0.27 | | 32.11 | 31.49 | -0.62 | | | | |

| News (112kbps , 15 fps) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Search Range=16 | | | | Search Range=32 | | | | | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| | 35.00 | 33.32 | -1.68 | | 32.87 | 31.57 | -1.30 | | | | |
| | 34.72 | 33.21 | -1.51 | | 33.17 | 32.05 | -1.12 | | | | |
| | 35.11 | 33.66 | -1.45 | | 32.98 | 31.88 | -1.10 | | | | |
| | 35.09 | 33.84 | -1.24 | | 32.87 | 31.80 | -1.06 | | | | |
| | 34.97 | 34.21 | -0.77 | | 33.17 | 32.21 | -0.96 | | | | |
| | 35.02 | 34.27 | -0.75 | | 32.22 | 31.26 | -0.96 | | | | |
| | 34.73 | 34.00 | -0.74 | | 32.74 | 31.86 | -0.89 | | | | |
| | 33.83 | 33.10 | -0.73 | | 31.99 | 31.18 | -0.80 | | | | |
| | 34.57 | 33.91 | -0.66 | | 32.18 | 31.42 | -0.76 | | | | |
| | 34.39 | 33.73 | -0.65 | | 32.11 | 31.49 | -0.62 | | | | |
| Foreman (112kbps , 10fps) | | | | | | | | | | | |
| Search Range=16 | | | | Search Range=32 | | | | | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| | 31.96 | 30.46 | -1.49 | | 32.01 | 30.85 | -1.16 | | | | |
| | 32.17 | 31.30 | -0.87 | | 31.75 | 30.79 | -0.96 | | | | |
| | 32.79 | 32.10 | -0.69 | | 32.20 | 31.42 | -0.78 | | | | |
| | 32.02 | 31.33 | -0.69 | | 32.07 | 31.33 | -0.75 | | | | |
| | 31.87 | 31.19 | -0.68 | | 32.19 | 31.50 | -0.68 | | | | |
| | 32.58 | 31.93 | -0.65 | | 31.57 | 30.92 | -0.66 | | | | |
| | 31.39 | 30.74 | -0.65 | | 32.39 | 31.73 | -0.66 | | | | |
| | 33.19 | 32.57 | -0.62 | | 31.33 | 30.70 | -0.64 | | | | |
| | 33.77 | 33.17 | -0.60 | | 31.44 | 30.83 | -0.62 | | | | |
| | 31.43 | 30.84 | -0.58 | | 31.88 | 31.27 | -0.61 | | | | |
| Coastguard (112kbps , 10fps) | | | | | | | | | | | |
| Search Range=16 | | | | Search Range=32 | | | | | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| | 27.76 | 27.38 | -0.39 | | 28.16 | 27.86 | -0.30 | | | | |
| | 28.30 | 27.95 | -0.35 | | 27.48 | 27.21 | -0.26 | | | | |
| | 27.60 | 27.27 | -0.33 | | 27.96 | 27.69 | -0.26 | | | | |
| | 27.22 | 26.93 | -0.29 | | 27.53 | 27.28 | -0.25 | | | | |
| | 27.63 | 27.35 | -0.28 | | 27.54 | 27.32 | -0.22 | | | | |
| | 27.42 | 27.20 | -0.22 | | 26.91 | 26.70 | -0.21 | | | | |
| | 27.18 | 26.96 | -0.22 | | 27.14 | 26.94 | -0.19 | | | | |
| | 27.61 | 27.41 | -0.20 | | 27.36 | 27.20 | -0.16 | | | | |
| | 26.72 | 26.53 | -0.19 | | 27.22 | 27.06 | -0.16 | | | | |
| | 28.34 | 28.17 | -0.18 | | 26.44 | 26.28 | -0.16 | | | | |

| Foreman (512kbps , 15 fps) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Search Range=16 | | | | Search Range=32 | | | | Search Range=48 | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ |
| | 37.65 | 37.32 | -0.33 | | 35.84 | 34.80 | -1.04 | | 35.33 | 34.21 | -1.13 |
| | 35.97 | 35.65 | -0.32 | | 37.01 | 36.07 | -0.94 | | 37.20 | 36.10 | -1.10 |
| | 35.52 | 35.22 | -0.30 | | 37.42 | 36.54 | -0.88 | | 35.80 | 34.72 | -1.08 |
| | 36.02 | 35.72 | -0.30 | | 34.73 | 33.87 | -0.86 | | 36.30 | 35.25 | -1.05 |
| | 35.98 | 35.68 | -0.29 | | 36.98 | 36.15 | -0.83 | | 36.98 | 35.98 | -1.00 |
| | 35.91 | 35.63 | -0.28 | | 36.73 | 35.93 | -0.80 | | 36.32 | 35.39 | -0.92 |
| | 34.54 | 34.27 | -0.27 | | 34.65 | 33.87 | -0.77 | | 37.17 | 36.32 | -0.85 |
| | 35.58 | 35.32 | -0.26 | | 35.91 | 35.24 | -0.67 | | 37.02 | 36.20 | -0.81 |
| | 35.61 | 35.36 | -0.25 | | 37.93 | 37.31 | -0.63 | | 37.49 | 36.71 | -0.77 |
| | 37.49 | 37.25 | -0.25 | | 36.31 | 35.75 | -0.56 | | 38.09 | 37.39 | -0.71 |
| Foreman (1024kbps , 30 fps) | | | | | | | | | | | |
| Search Range=16 | | | | Search Range=32 | | | | Search Range=48 | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ |
| | 38.15 | 37.32 | -0.83 | | 37.64 | 36.70 | -0.95 | | 37.66 | 36.73 | -0.93 |
| | 37.59 | 36.76 | -0.83 | | 38.37 | 37.47 | -0.90 | | 37.63 | 36.77 | -0.86 |
| | 38.25 | 37.45 | -0.80 | | 38.23 | 37.34 | -0.89 | | 38.45 | 37.67 | -0.79 |
| | 38.22 | 37.43 | -0.79 | | 37.65 | 36.78 | -0.87 | | 38.19 | 37.41 | -0.78 |
| | 38.40 | 37.64 | -0.76 | | 38.42 | 37.56 | -0.86 | | 38.36 | 37.60 | -0.75 |
| | 38.23 | 37.52 | -0.71 | | 38.53 | 37.70 | -0.84 | | 38.24 | 37.49 | -0.75 |
| | 37.85 | 37.15 | -0.70 | | 38.17 | 37.40 | -0.77 | | 37.80 | 37.06 | -0.74 |
| | 37.48 | 36.80 | -0.68 | | 38.45 | 37.72 | -0.73 | | 38.41 | 37.67 | -0.73 |
| | 37.15 | 36.51 | -0.64 | | 37.78 | 37.05 | -0.73 | | 38.39 | 37.72 | -0.68 |
| | 37.30 | 36.67 | -0.62 | | 38.71 | 37.98 | -0.73 | | 38.52 | 37.87 | -0.64 |
| Table Tennis (1024kbps , 30fps) | | | | | | | | | | | |
| Search Range=16 | | | | Search Range=32 | | | | Search Range=48 | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ |
| | 32.49 | 31.95 | -0.54 | | 34.20 | 33.71 | -0.50 | | 32.44 | 31.90 | -0.54 |
| | 33.24 | 32.74 | -0.51 | | 32.54 | 32.06 | -0.48 | | 34.57 | 34.09 | -0.48 |
| | 32.68 | 32.22 | -0.47 | | 33.18 | 32.71 | -0.47 | | 33.32 | 32.84 | -0.48 |
| | 34.63 | 34.19 | -0.44 | | 34.60 | 34.13 | -0.47 | | 34.76 | 34.30 | -0.46 |
| | 34.52 | 34.09 | -0.43 | | 34.75 | 34.29 | -0.46 | | 32.52 | 32.06 | -0.45 |
| | 35.17 | 34.74 | -0.43 | | 34.11 | 33.66 | -0.45 | | 34.01 | 33.56 | -0.45 |
| | 34.52 | 34.10 | -0.43 | | 33.60 | 33.15 | -0.45 | | 34.72 | 34.28 | -0.44 |
| | 34.73 | 34.31 | -0.42 | | 34.50 | 34.06 | -0.44 | | 35.55 | 35.12 | -0.44 |
| | 32.61 | 32.20 | -0.41 | | 32.41 | 31.98 | -0.44 | | 34.49 | 34.05 | -0.43 |
| | 34.78 | 34.39 | -0.39 | | 34.20 | 33.78 | -0.42 | | 32.66 | 32.23 | -0.43 |

| Table Tennis (2048kbps , 30 fps) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Search Range=16 | | | | Search Range=32 | | | | Search Range=48 | | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | |
| | 37.82 | 37.34 | -0.48 | | 37.68 | 37.14 | -0.54 | | 37.64 | 37.12 | -0.52 | |
| | 37.71 | 37.24 | -0.47 | | 37.71 | 37.19 | -0.52 | | 37.82 | 37.34 | -0.48 | |
| | 37.68 | 37.22 | -0.47 | | 37.64 | 37.12 | -0.52 | | 38.10 | 37.65 | -0.46 | |
| | 38.11 | 37.66 | -0.45 | | 37.87 | 37.38 | -0.48 | | 37.74 | 37.30 | -0.44 | |
| | 37.67 | 37.24 | -0.43 | | 38.07 | 37.65 | -0.42 | | 37.61 | 37.23 | -0.37 | |
| | 37.64 | 37.22 | -0.43 | | 37.99 | 37.59 | -0.40 | | 38.25 | 37.88 | -0.37 | |
| | 36.27 | 35.86 | -0.40 | | 37.61 | 37.23 | -0.38 | | 37.94 | 37.57 | -0.37 | |
| | 36.06 | 35.66 | -0.40 | | 37.75 | 37.37 | -0.38 | | 38.08 | 37.72 | -0.37 | |
| | 37.97 | 37.58 | -0.40 | | 37.71 | 37.33 | -0.37 | | 37.47 | 37.11 | -0.36 | |
| | 37.77 | 37.38 | -0.39 | | 38.01 | 37.64 | -0.37 | | 36.21 | 35.85 | -0.36 | |
| Bus (4000kbps , 30 fps) | | | | | | | | | | | | |
| Search Range=64 | | | | Search Range=128 | | | | | | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | | |
| | 29.98 | 28.62 | -1.36 | | 30.21 | 28.81 | -1.40 | | | | | |
| | 30.02 | 28.66 | -1.36 | | 29.96 | 28.60 | -1.37 | | | | | |
| | 30.25 | 28.90 | -1.35 | | 30.15 | 28.83 | -1.31 | | | | | |
| | 29.95 | 28.68 | -1.27 | | 29.33 | 28.05 | -1.29 | | | | | |
| | 29.33 | 28.07 | -1.27 | | 29.96 | 28.72 | -1.24 | | | | | |
| | 30.14 | 28.91 | -1.23 | | 30.41 | 29.19 | -1.23 | | | | | |
| | 31.44 | 30.26 | -1.18 | | 30.02 | 28.81 | -1.21 | | | | | |
| | 30.43 | 29.25 | -1.18 | | 30.23 | 29.01 | -1.21 | | | | | |
| | 29.98 | 28.82 | -1.17 | | 29.97 | 28.77 | -1.20 | | | | | |
| | 29.46 | 28.30 | -1.16 | | 30.13 | 28.93 | -1.19 | | | | | |
| Bus (9000kbps , 30fps) | | | | | | | | | | | | |
| Search Range=64 | | | | Search Range=128 | | | | | | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | | |
| | 34.26 | 32.97 | -1.29 | | 34.24 | 32.97 | -1.27 | | | | | |
| | 34.21 | 32.94 | -1.27 | | 34.24 | 33.04 | -1.21 | | | | | |
| | 34.31 | 33.05 | -1.26 | | 34.22 | 33.03 | -1.19 | | | | | |
| | 34.25 | 32.99 | -1.26 | | 34.72 | 33.56 | -1.16 | | | | | |
| | 34.29 | 33.05 | -1.25 | | 34.22 | 33.08 | -1.14 | | | | | |
| | 34.15 | 32.91 | -1.23 | | 34.03 | 32.89 | -1.14 | | | | | |
| | 34.18 | 32.95 | -1.22 | | 34.25 | 33.11 | -1.14 | | | | | |
| | 34.24 | 33.03 | -1.21 | | 34.00 | 32.87 | -1.13 | | | | | |
| | 34.55 | 33.36 | -1.18 | | 34.16 | 33.03 | -1.12 | | | | | |
| | 34.28 | 33.10 | -1.18 | | 34.19 | 33.08 | -1.11 | | | | | |

| Basketball (4000kbps , 30 fps) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Search Range=64 | | | | Search Range=128 | | | | | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| | 28.91 | 27.77 | -1.14 | | 28.76 | 27.37 | -1.39 | | | | |
| | 28.74 | 27.60 | -1.14 | | 28.86 | 27.53 | -1.33 | | | | |
| | 28.88 | 27.78 | -1.11 | | 28.87 | 27.69 | -1.17 | | | | |
| | 27.27 | 26.26 | -1.01 | | 28.69 | 27.56 | -1.13 | | | | |
| | 28.85 | 27.85 | -1.00 | | 28.84 | 27.79 | -1.05 | | | | |
| | 28.66 | 27.69 | -0.97 | | 28.83 | 27.86 | -0.97 | | | | |
| | 28.77 | 27.91 | -0.87 | | 27.25 | 26.29 | -0.95 | | | | |
| | 27.33 | 26.46 | -0.86 | | 27.10 | 26.20 | -0.90 | | | | |
| | 27.17 | 26.31 | -0.86 | | 27.35 | 26.46 | -0.89 | | | | |
| | 28.87 | 28.02 | -0.85 | | 28.61 | 27.75 | -0.86 | | | | |
| Baketball (9000kbps , 30fps) | | | | | | | | | | | |
| Search Range=64 | | | | Search Range=128 | | | | | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| | 33.53 | 31.57 | -1.95 | | 33.62 | 31.28 | -2.34 | | | | |
| | 33.60 | 32.09 | -1.51 | | 33.52 | 31.54 | -1.98 | | | | |
| | 33.63 | 32.33 | -1.30 | | 33.62 | 31.91 | -1.71 | | | | |
| | 33.33 | 32.23 | -1.10 | | 33.35 | 32.14 | -1.21 | | | | |
| | 29.84 | 28.81 | -1.03 | | 31.50 | 30.44 | -1.06 | | | | |
| | 31.52 | 30.51 | -1.01 | | 31.18 | 30.18 | -1.00 | | | | |
| | 29.56 | 28.56 | -1.00 | | 31.70 | 30.75 | -0.95 | | | | |
| | 31.75 | 30.76 | -0.99 | | 31.87 | 30.94 | -0.93 | | | | |
| | 29.97 | 29.03 | -0.94 | | 30.89 | 29.96 | -0.93 | | | | |
| | 29.90 | 28.97 | -0.93 | | 30.62 | 29.71 | -0.92 | | | | |
| Cheerleader (4000kbps , 30 fps) | | | | | | | | | | | |
| Search Range=64 | | | | Search Range=128 | | | | | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| | 30.41 | 30.03 | -0.37 | | 30.97 | 30.60 | -0.36 | | | | |
| | 30.37 | 30.01 | -0.36 | | 30.36 | 30.00 | -0.36 | | | | |
| | 30.40 | 30.08 | -0.32 | | 30.31 | 29.97 | -0.34 | | | | |
| | 31.01 | 30.70 | -0.31 | | 30.39 | 30.07 | -0.32 | | | | |
| | 30.95 | 30.64 | -0.30 | | 30.86 | 30.55 | -0.31 | | | | |
| | 30.91 | 30.61 | -0.30 | | 30.88 | 30.57 | -0.30 | | | | |
| | 30.85 | 30.56 | -0.29 | | 29.51 | 29.24 | -0.26 | | | | |
| | 28.43 | 28.19 | -0.24 | | 29.43 | 29.18 | -0.25 | | | | |
| | 29.43 | 29.20 | -0.23 | | 30.94 | 30.70 | -0.25 | | | | |
| | 29.28 | 29.05 | -0.23 | | 29.24 | 29.01 | -0.23 | | | | |

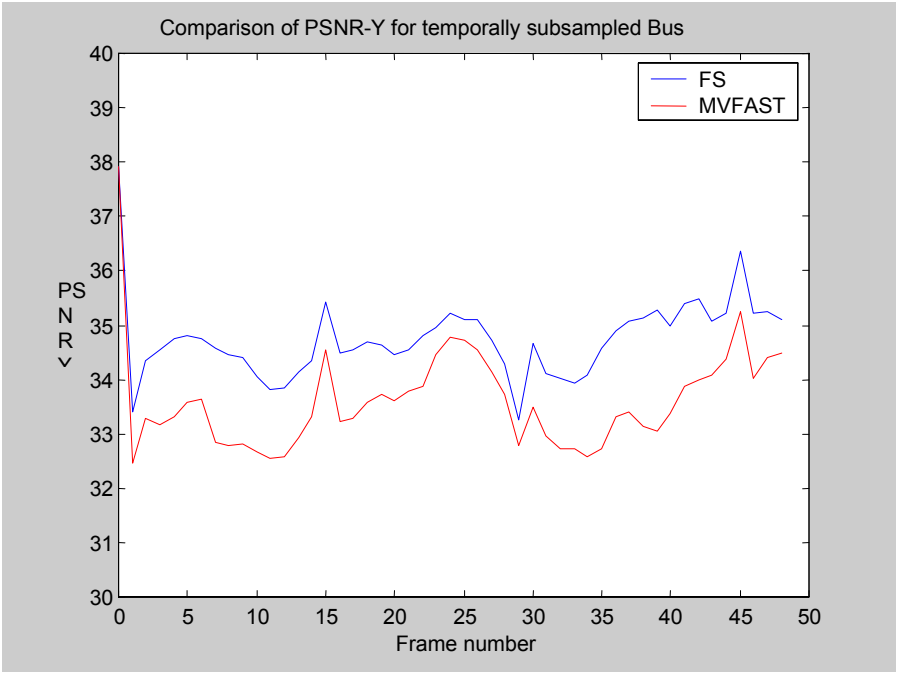
| Cheerleader (9000kbps , 30fps) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Search Range=64 | | | | Search Range=128 | | | | | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| | 35.05 | 34.86 | -0.19 | | 35.04 | 34.80 | -0.24 | | | | |
| | 34.16 | 33.98 | -0.19 | | 34.38 | 34.19 | -0.19 | | | | |
| | 34.53 | 34.35 | -0.18 | | 34.51 | 34.32 | -0.19 | | | | |
| | 35.31 | 35.14 | -0.17 | | 35.30 | 35.12 | -0.18 | | | | |
| | 35.86 | 35.71 | -0.15 | | 35.86 | 35.70 | -0.16 | | | | |
| | 35.25 | 35.10 | -0.14 | | 35.25 | 35.09 | -0.16 | | | | |
| | 34.38 | 34.24 | -0.14 | | 33.68 | 33.55 | -0.13 | | | | |
| | 35.05 | 34.92 | -0.14 | | 33.94 | 33.82 | -0.12 | | | | |
| | 33.71 | 33.59 | -0.12 | | 35.06 | 34.93 | -0.12 | | | | |
| | 35.22 | 35.10 | -0.12 | | 33.96 | 33.85 | -0.11 | | | | |
| Stefan (4000kbps , 30 fps) | | | | | | | | | | | |
| Search Range=64 | | | | Search Range=128 | | | | | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| | 31.35 | 27.28 | -4.06 | | 31.39 | 27.22 | -4.17 | | | | |
| | 31.23 | 27.32 | -3.90 | | 31.26 | 27.28 | -3.98 | | | | |
| | 30.98 | 27.48 | -3.50 | | 31.03 | 27.31 | -3.72 | | | | |
| | 30.26 | 26.92 | -3.35 | | 29.63 | 26.30 | -3.34 | | | | |
| | 30.70 | 27.43 | -3.28 | | 30.28 | 27.01 | -3.27 | | | | |
| | 29.77 | 26.60 | -3.17 | | 30.76 | 27.53 | -3.23 | | | | |
| | 30.82 | 27.69 | -3.13 | | 29.74 | 26.56 | -3.17 | | | | |
| | 29.91 | 26.84 | -3.08 | | 29.94 | 26.84 | -3.10 | | | | |
| | 29.92 | 26.84 | -3.08 | | 29.50 | 26.48 | -3.02 | | | | |
| | 29.84 | 26.82 | -3.03 | | 29.88 | 26.90 | -2.98 | | | | |
| Stefan (9000kbps , 30fps) | | | | | | | | | | | |
| Search Range=64 | | | | Search Range=128 | | | | | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| | 36.25 | 33.08 | -3.16 | | 36.28 | 33.23 | -3.04 | | | | |
| | 35.96 | 33.19 | -2.78 | | 34.45 | 31.44 | -3.01 | | | | |
| | 34.79 | 32.08 | -2.71 | | 34.44 | 31.46 | -2.98 | | | | |
| | 34.77 | 32.14 | -2.63 | | 34.29 | 31.43 | -2.86 | | | | |
| | 34.81 | 32.19 | -2.61 | | 34.75 | 31.94 | -2.81 | | | | |
| | 34.71 | 32.20 | -2.51 | | 34.40 | 31.68 | -2.72 | | | | |
| | 35.70 | 33.23 | -2.47 | | 35.97 | 33.25 | -2.72 | | | | |
| | 35.50 | 33.05 | -2.46 | | 34.81 | 32.13 | -2.69 | | | | |
| | 34.52 | 32.12 | -2.40 | | 34.74 | 32.06 | -2.68 | | | | |
| | 34.76 | 32.40 | -2.36 | | 34.80 | 32.25 | -2.55 | | | | |

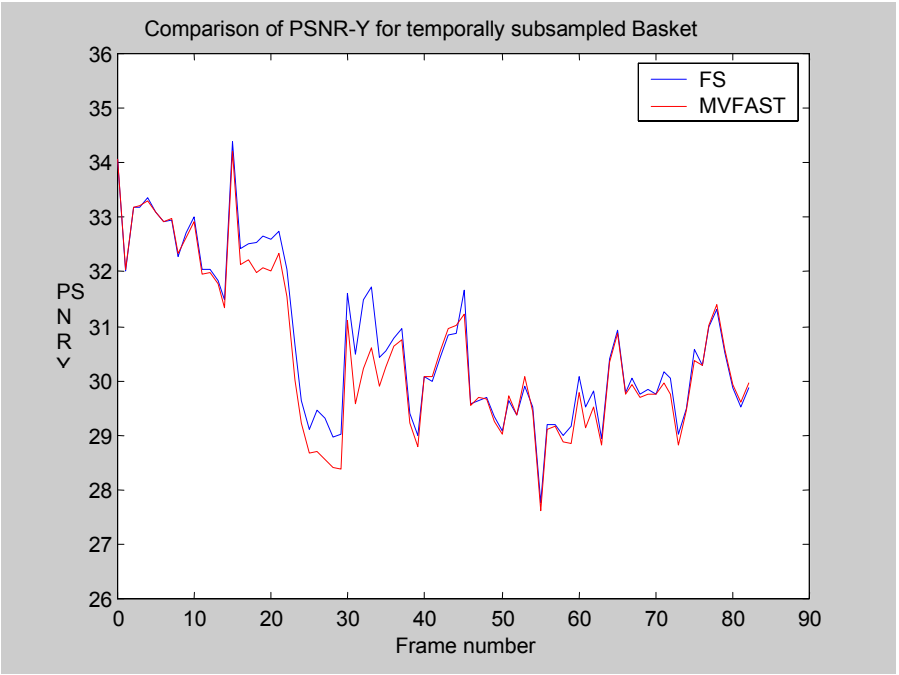
| Flower Garden (4000kbps , 30 fps) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Search Range=64 | | | | Search Range=128 | | | | | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| | 29.26 | 28.66 | -0.60 | | 29.17 | 28.58 | -0.58 | | | | |
| | 29.16 | 28.63 | -0.53 | | 30.31 | 29.78 | -0.53 | | | | |
| | 30.35 | 29.84 | -0.51 | | 29.14 | 28.62 | -0.52 | | | | |
| | 30.22 | 29.75 | -0.47 | | 30.20 | 29.74 | -0.47 | | | | |
| | 28.74 | 28.32 | -0.43 | | 28.71 | 28.27 | -0.44 | | | | |
| | 29.51 | 29.10 | -0.41 | | 27.49 | 27.08 | -0.41 | | | | |
| | 29.22 | 28.81 | -0.41 | | 29.26 | 28.85 | -0.41 | | | | |
| | 27.48 | 27.07 | -0.41 | | 30.32 | 29.92 | -0.39 | | | | |
| | 30.34 | 29.94 | -0.40 | | 30.40 | 30.01 | -0.39 | | | | |
| | 27.46 | 27.07 | -0.39 | | 29.24 | 28.86 | -0.39 | | | | |
| Flower Garden (9000kbps , 30fps) | | | | | | | | | | | |
| Search Range=64 | | | | Search Range=128 | | | | | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| | 34.31 | 33.73 | -0.58 | | 34.30 | 33.73 | -0.57 | | | | |
| | 33.89 | 33.32 | -0.57 | | 34.33 | 33.79 | -0.55 | | | | |
| | 34.34 | 33.80 | -0.54 | | 34.01 | 33.48 | -0.53 | | | | |
| | 34.01 | 33.50 | -0.52 | | 33.88 | 33.36 | -0.51 | | | | |
| | 33.50 | 33.01 | -0.49 | | 33.50 | 33.00 | -0.50 | | | | |
| | 34.64 | 34.15 | -0.49 | | 34.63 | 34.15 | -0.48 | | | | |
| | 34.44 | 33.97 | -0.47 | | 34.43 | 33.96 | -0.47 | | | | |
| | 34.84 | 34.40 | -0.45 | | 34.84 | 34.38 | -0.45 | | | | |
| | 33.91 | 33.47 | -0.44 | | 33.89 | 33.45 | -0.45 | | | | |
| | 32.92 | 32.48 | -0.44 | | 32.91 | 32.46 | -0.44 | | | | |
| Bus Subsampled at 3:1 (12000kbps , 30 fps) | | | | | | | | | | | |
| Search Range=128 | | | | | | | | | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | | | | | |
| | 35.28 | 33.05 | -2.23 | | | | | | | | |
| | 35.12 | 33.13 | -1.99 | | | | | | | | |
| | 34.56 | 32.71 | -1.85 | | | | | | | | |
| | 34.58 | 32.85 | -1.72 | | | | | | | | |
| | 34.46 | 32.77 | -1.68 | | | | | | | | |
| | 35.07 | 33.40 | -1.67 | | | | | | | | |
| | 34.98 | 33.38 | -1.60 | | | | | | | | |
| | 34.90 | 33.32 | -1.59 | | | | | | | | |
| | 34.41 | 32.82 | -1.59 | | | | | | | | |
| | 35.39 | 33.87 | -1.51 | | | | | | | | |

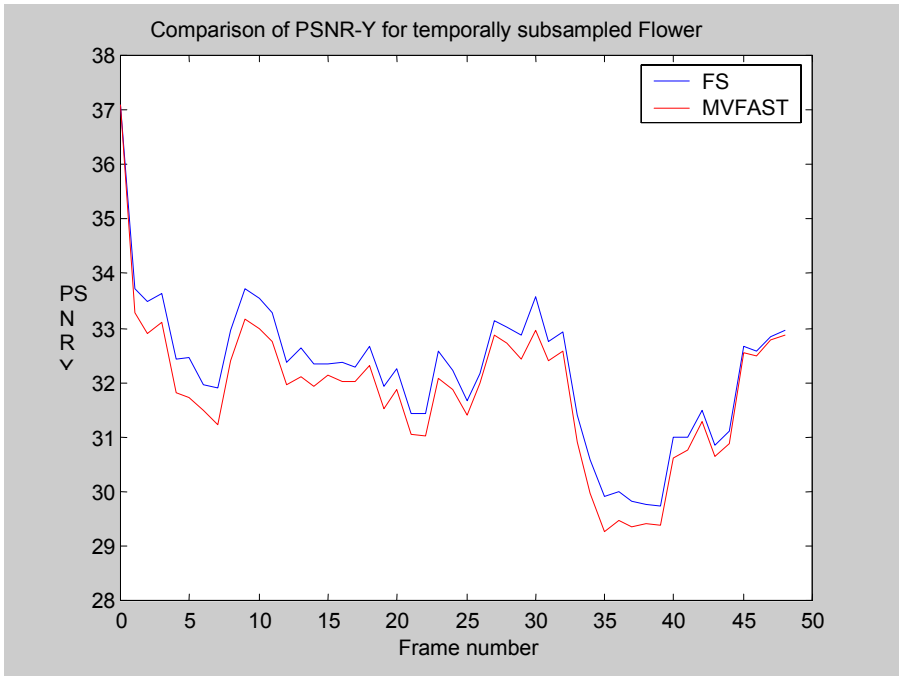
| Basket Subsampled at 3:1 (12000kbps , 30fps) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Search Range=128 | | | | | | | | | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | | | | | |
| | 31.48 | 30.23 | -1.25 | | | | | | | | |
| | 31.72 | 30.60 | -1.11 | | | | | | | | |
| | 30.48 | 29.58 | -0.90 | | | | | | | | |
| | 29.33 | 28.56 | -0.77 | | | | | | | | |
| | 29.45 | 28.70 | -0.75 | | | | | | | | |
| | 30.67 | 30.02 | -0.65 | | | | | | | | |
| | 29.02 | 28.37 | -0.65 | | | | | | | | |
| | 32.61 | 32.00 | -0.60 | | | | | | | | |
| | 32.66 | 32.08 | -0.58 | | | | | | | | |
| | 32.53 | 31.98 | -0.55 | | | | | | | | |
| Stefan Subsampled at 3:1 (12000kbps , 30 fps) | | | | | | | | | | | |
| Search Range=128 | | | | | | | | | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | | | | | |
| | 35.28 | 33.48 | -1.81 | | | | | | | | |
| | 35.17 | 33.59 | -1.58 | | | | | | | | |
| | 36.35 | 34.78 | -1.57 | | | | | | | | |
| | 35.71 | 34.20 | -1.51 | | | | | | | | |
| | 34.92 | 33.42 | -1.50 | | | | | | | | |
| | 35.41 | 33.92 | -1.49 | | | | | | | | |
| | 36.13 | 34.64 | -1.49 | | | | | | | | |
| | 35.20 | 33.73 | -1.47 | | | | | | | | |
| | 34.79 | 33.33 | -1.46 | | | | | | | | |
| | 35.91 | 34.45 | -1.46 | | | | | | | | |
| Flower subsampled at 3:1 (12000kbps , 30fps) | | | | | | | | | | | |
| Search Range=128 | | | | | | | | | | | |
| | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | | | | | |
| | 32.47 | 31.72 | -0.75 | | | | | | | | |
| | 31.90 | 31.22 | -0.68 | | | | | | | | |
| | 29.89 | 29.25 | -0.64 | | | | | | | | |
| | 30.59 | 29.97 | -0.63 | | | | | | | | |
| | 32.41 | 31.81 | -0.60 | | | | | | | | |
| | 33.57 | 32.97 | -0.60 | | | | | | | | |
| | 33.50 | 32.90 | -0.60 | | | | | | | | |
| | 33.73 | 33.17 | -0.57 | | | | | | | | |
| | 32.95 | 32.39 | -0.56 | | | | | | | | |
| | 33.54 | 32.99 | -0.55 | | | | | | | | |

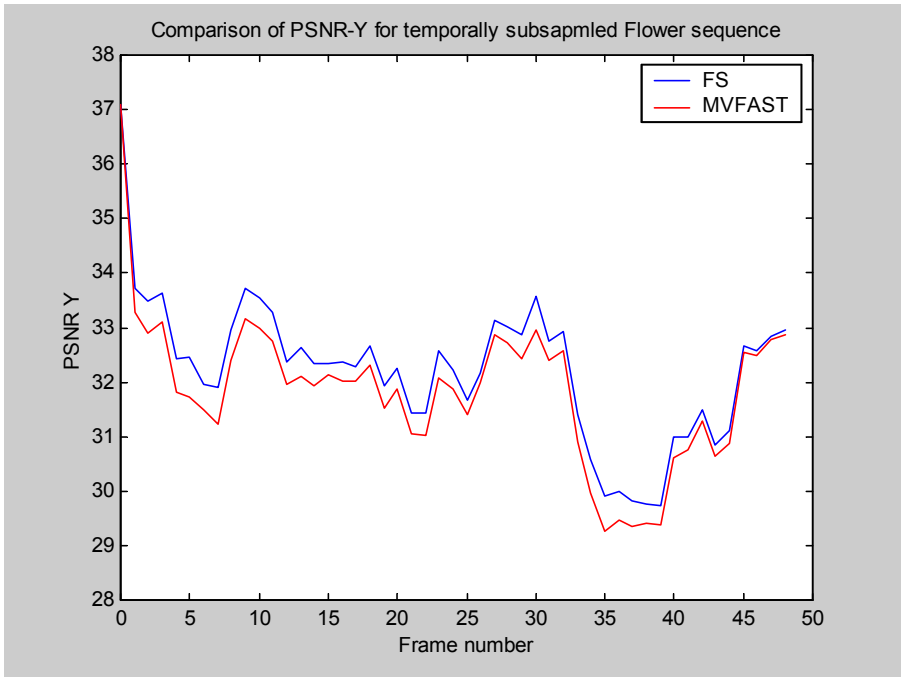
# APPENDIX C

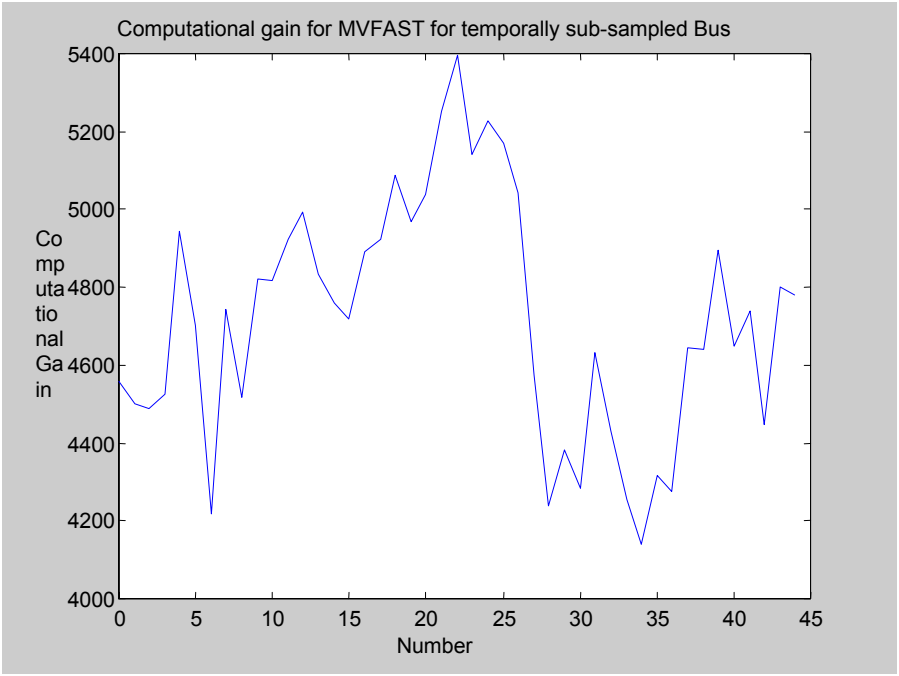
## The graphs of number of Computational Gain and PSNR-Y for each frame for the four sub-sampled sequences

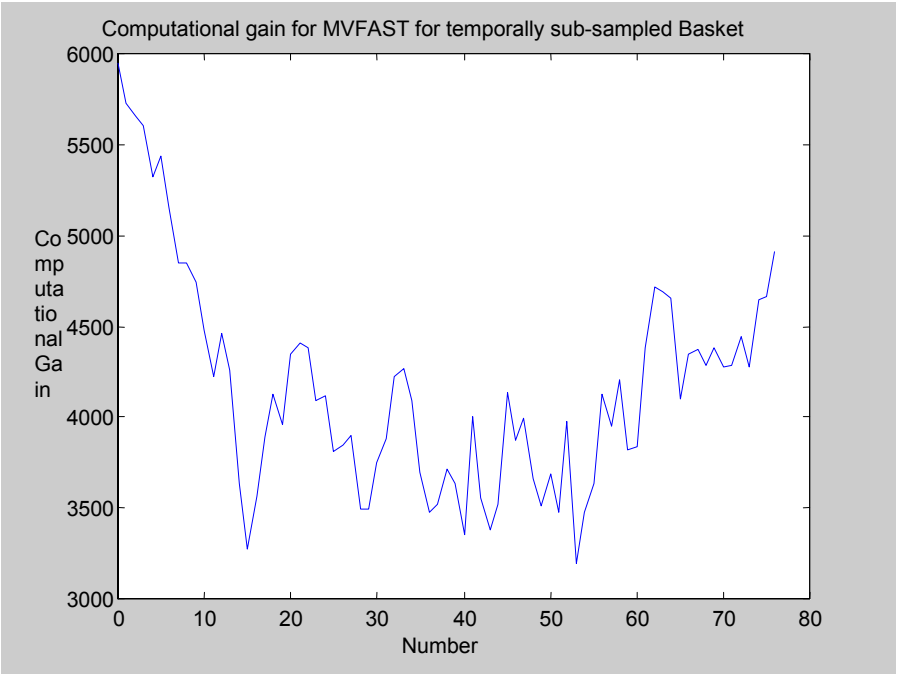

Comparison of PSNR-Y for temporally subsampled Bus
FS
MVFAST
PSNRY
Frame number

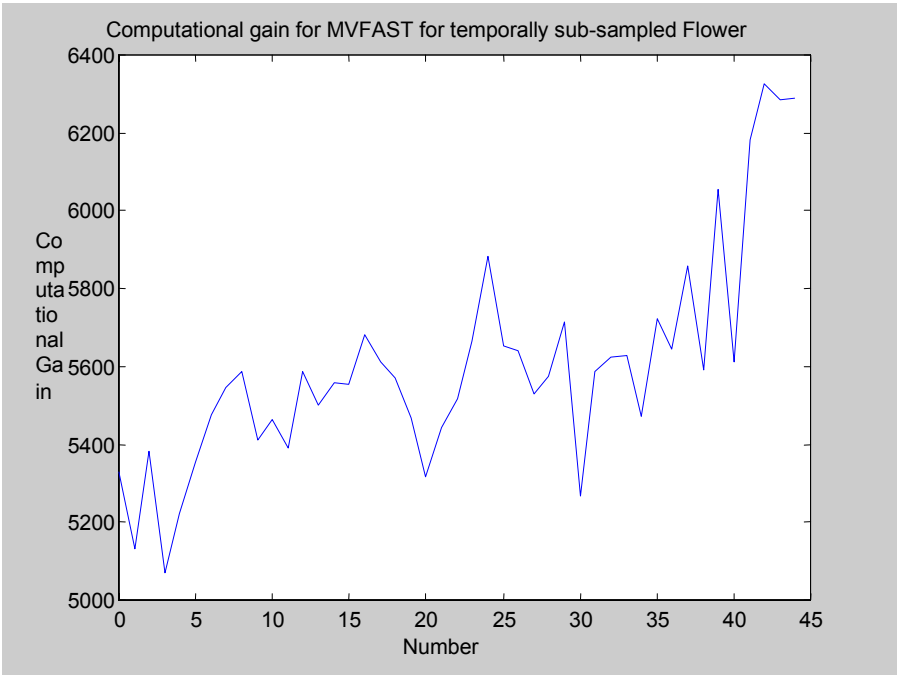

Comparison of PSNR-Y for temporally subsampled Basket
FS
MVFAST
PSNRY
Frame number

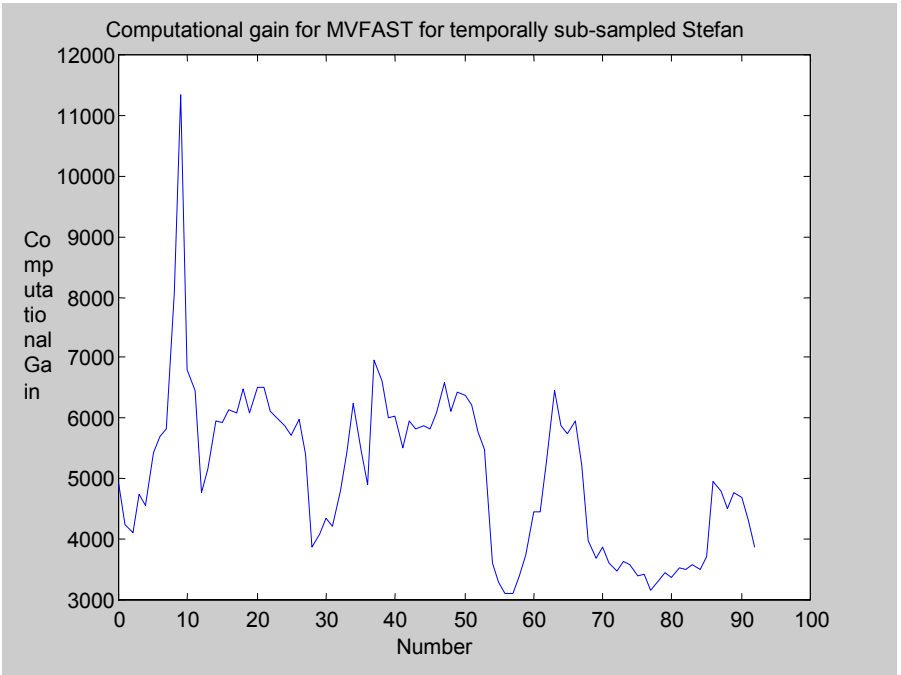

Comparison of PSNR-Y for temporally subsampled Flower
FS
MVFAST
PSNRY
Frame number


Comparison of PSNR-Y for temporally subsapmled Flower sequence
FS
MVFAST
PSNR Y
Frame number


Computational gain for MVFAST for temporally sub-sampled Bus
Computational Gain
Number
5400
5200
5000
4800
4600
4400
4200
4000
0
5
10
15
20
25
30
35
40
45


Computational gain for MVFAST for temporally sub-sampled Basket
Computational Gain
Number
6000
5500
5000
4500
4000
3500
3000
0
10
20
30
40
50
60
70
80


Computational gain for MVFAST for temporally sub-sampled Flower
Computational Gain
Number
6400
6200
6000
5800
5600
5400
5200
5000
0
5
10
15
20
25
30
35
40
45


Computational gain for MVFAST for temporally sub-sampled Stefan
Computational Gain
Number
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
0
10
20
30
40
50
60
70
80
90
100

# APPENDIX-D

| Sequence | Bitrate (kbps) | Frame Rate (fps) | Search Range | PSNR-Y | | PSNR-U | | PSNR-V | | SEARCH POINTS | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | FS | STMVFAST | FS | STMVFAST | FS | STMVFAST | FS | STMVFAST |
| container | 10 | 7.5 | 16 | 29.81 | 29.78 | 37.54 | 37.50 | 36.60 | 36.64 | 7501824 | 32272 |
| container | 10 | 7.5 | 32 | 29.72 | 29.68 | 37.55 | 37.41 | 36.57 | 36.53 | 27142090 | 33238 |
| Hall monitor | 10 | 7.5 | 16 | 30.35 | 30.32 | 36.38 | 36.31 | 39.57 | 39.52 | 7501824 | 30223 |
| Hall monitor | 10 | 7.5 | 32 | 30.29 | 30.33 | 36.24 | 36.51 | 39.49 | 39.62 | 27142090 | 29628 |
| Mother Dtr | 24 | 10 | 16 | 34.80 | 34.77 | 40.23 | 40.25 | 41.02 | 41.03 | 10036224 | 42964 |
| Mother Dtr | 24 | 10 | 32 | 34.81 | 34.71 | 40.28 | 40.32 | 40.98 | 41.00 | 36311715 | 43226 |
| Silence | 24 | 10 | 16 | 30.85 | 30.90 | 35.56 | 35.65 | 36.93 | 36.99 | 10036224 | 63153 |
| Silence | 24 | 10 | 32 | 30.78 | 30.86 | 35.42 | 35.68 | 36.90 | 37.01 | 36311715 | 62630 |
| Coastguard | 48 | 10 | 16 | 28.88 | 28.87 | 40.14 | 40.18 | 42.07 | 41.96 | 10036224 | 66775 |
| Coastguard | 48 | 10 | 32 | 28.90 | 28.87 | 40.02 | 40.20 | 41.88 | 41.99 | 36311715 | 66810 |
| News | 48 | 7.5 | 16 | 31.84 | 31.83 | 35.72 | 36.00 | 37.31 | 37.54 | 30007296 | 148637 |
| News | 48 | 7.5 | 32 | 31.90 | 31.84 | 35.79 | 36.04 | 37.35 | 37.54 | 114227658 | 152100 |
| News | 112 | 15 | 16 | 34.05 | 33.94 | 38.04 | 38.00 | 38.93 | 38.94 | 60420096 | 234473 |
| News | 112 | 15 | 32 | 34.03 | 33.94 | 37.93 | 37.91 | 38.85 | 38.83 | 229998933 | 237120 |
| Foreman | 112 | 10 | 16 | 30.04 | 29.93 | 36.78 | 36.85 | 37.53 | 37.76 | 40144896 | 394787 |
| Foreman | 112 | 10 | 32 | 30.37 | 30.19 | 36.88 | 37.01 | 37.56 | 37.88 | 152818083 | 413699 |
| Coastguard | 112 | 10 | 16 | 27.03 | 27.11 | 38.87 | 39.12 | 41.65 | 41.85 | 40144896 | 340770 |
| Coastguard | 112 | 10 | 32 | 27.06 | 27.19 | 38.64 | 38.90 | 40.99 | 41.20 | 152818083 | 337969 |
| Foreman | 512 | 15 | 16 | 34.51 | 34.48 | 40.25 | 40.25 | 41.47 | 41.50 | 56770560 | 447678 |
| Foreman | 512 | 15 | 32 | 34.84 | 34.77 | 40.56 | 40.52 | 41.75 | 41.74 | 216106380 | 455610 |
| Foreman | 512 | 15 | 48 | 34.88 | 34.79 | 40.62 | 40.55 | 41.79 | 41.78 | 461637680 | 457232 |
| Foreman | 1024 | 30 | 16 | 35.47 | 35.41 | 41.05 | 41.00 | 42.36 | 42.32 | 113541120 | 670077 |
| Foreman | 1024 | 30 | 32 | 35.53 | 35.47 | 41.13 | 41.06 | 42.43 | 42.37 | 432212760 | 681741 |
| Foreman | 1024 | 30 | 48 | 35.51 | 35.44 | 41.11 | 41.05 | 42.40 | 42.36 | 923275360 | 681898 |
| Tennis | 1024 | 30 | 16 | 34.98 | 34.96 | 41.89 | 41.85 | 41.01 | 40.97 | 94617600 | 397932 |
| Tennis | 1024 | 30 | 32 | 35.00 | 34.95 | 41.91 | 41.84 | 41.02 | 40.96 | 358185240 | 401483 |
| Tennis | 1024 | 30 | 48 | 34.97 | 34.95 | 41.88 | 41.84 | 41.01 | 40.96 | 760543840 | 401675 |
| Tennis | 2048 | 30 | 16 | 37.95 | 37.94 | 43.47 | 43.44 | 42.98 | 42.95 | 94617600 | 354219 |
| Tennis | 2048 | 30 | 32 | 37.95 | 37.92 | 43.47 | 43.44 | 42.97 | 42.94 | 358185240 | 356144 |
| Tennis | 2048 | 30 | 48 | 37.94 | 37.92 | 43.45 | 43.43 | 42.96 | 42.94 | 760543840 | 356585 |

| Sequence | Bitrate (kbps) | Frame Rate (fps) | Search Range | PSNR-Y | | PSNR-U | | PSNR-V | | SEARCH POINTS | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | FS | STMVFAST | FS | STMVFAST | FS | STMVFAST | FS | STMVFAST |
| Bus | 4000 | 30 | 64 | 29.78 | 29.50 | 37.53 | 37.51 | 39.73 | 39.70 | 2827221219 | 1274803 |
| Bus | 4000 | 30 | 128 | 29.78 | 29.48 | 37.50 | 37.50 | 39.69 | 39.69 | 10035121819 | 1274805 |
| Bus | 9000 | 30 | 64 | 34.03 | 33.88 | 39.18 | 39.23 | 41.65 | 41.68 | 2827221219 | 1190289 |
| Bus | 9000 | 30 | 128 | 34.03 | 33.87 | 39.17 | 39.22 | 41.64 | 41.67 | 10035121819 | 1191786 |
| Basket Ball | 4000 | 30 | 64 | 26.71 | 26.46 | 33.37 | 33.42 | 33.32 | 33.35 | 5580207144 | 3089444 |
| Basket Ball | 4000 | 30 | 128 | 26.67 | 26.43 | 33.33 | 33.41 | 33.29 | 33.33 | 20043089232 | 3094300 |
| Basket Ball | 9000 | 30 | 64 | 30.78 | 30.54 | 35.74 | 35.74 | 35.60 | 35.59 | 5580207144 | 2934474 |
| Basket Ball | 9000 | 30 | 128 | 30.76 | 30.53 | 35.72 | 35.73 | 35.59 | 35.58 | 20043089232 | 2938303 |
| Cheerleader | 4000 | 30 | 64 | 29.27 | 29.15 | 31.68 | 31.74 | 32.72 | 32.84 | 2827221219 | 1696334 |
| Cheerleader | 4000 | 30 | 128 | 29.25 | 29.13 | 31.66 | 31.72 | 32.69 | 32.82 | 10035121819 | 1702557 |
| Cheerleader | 9000 | 30 | 64 | 33.65 | 33.65 | 35.24 | 35.34 | 36.08 | 36.22 | 2827221219 | 1617194 |
| Cheerleader | 9000 | 30 | 128 | 33.64 | 33.64 | 35.24 | 35.33 | 36.08 | 36.21 | 10035121819 | 1620837 |
| Stefan | 4000 | 30 | 64 | 30.77 | 30.44 | 36.29 | 36.24 | 36.25 | 36.21 | 5695121880 | 2413533 |
| Stefan | 4000 | 30 | 128 | 30.77 | 30.43 | 36.28 | 36.24 | 36.23 | 36.20 | 20214633880 | 2421060 |
| Stefan | 9000 | 30 | 64 | 34.97 | 34.79 | 38.99 | 38.93 | 39.09 | 39.04 | 5695121880 | 2304416 |
| Stefan | 9000 | 30 | 128 | 34.97 | 34.78 | 38.99 | 38.92 | 39.09 | 39.02 | 20214633880 | 2311897 |
| Flower | 4000 | 30 | 64 | 28.33 | 28.18 | 32.08 | 32.02 | 33.99 | 33.97 | 2827221219 | 1002213 |
| Flower Gdn. | 4000 | 30 | 128 | 28.31 | 28.16 | 32.06 | 32.00 | 33.98 | 33.96 | 10035121819 | 1001107 |
| Flower Gdn. | 9000 | 30 | 64 | 33.17 | 33.04 | 35.47 | 35.42 | 36.38 | 36.35 | 2827221219 | 979916 |
| Flower Gdn. | 9000 | 30 | 128 | 33.16 | 33.02 | 35.46 | 35.41 | 36.38 | 36.35 | 10035121819 | 980137 |
| Bus Subs. 3:1 | 12000 | 30 | 128 | 34.74 | 34.26 | 39.20 | 39.19 | 41.64 | 41.57 | 3248780445 | 519313 |
| Basket Subs. 3:1 | 12000 | 30 | 128 | 30.71 | 30.55 | 35.63 | 35.83 | 35.50 | 35.66 | 6652232125 | 1431657 |
| Stefan Subs. 3:1 | 12000 | 30 | 128 | 35.20 | 34.85 | 39.02 | 38.90 | 39.03 | 38.91 | 6714146253 | 1189285 |
| Flower Subs. 3:1 | 12000 | 30 | 128 | 32.22 | 31.93 | 34.34 | 34.23 | 35.51 | 35.44 | 3248780445 | 440686 |

| Sequence | Bitrate (kbps) | Frame Rate (fps) | Search Range | $\delta_{PSNR-Y}$ | $\delta_{PSNR-U}$ | $\delta_{PSNR-V}$ | COMPUTATIONAL GAIN |
|---|---|---|---|---|---|---|---|
| container | 10 | 7.5 | 16 | -0.03 | -0.04 | 0.04 | 232 |
| container | 10 | 7.5 | 32 | -0.04 | -0.14 | -0.04 | 817 |
| Hall monitor | 10 | 7.5 | 16 | -0.03 | -0.07 | -0.05 | 248 |
| Hall monitor | 10 | 7.5 | 32 | 0.04 | 0.27 | 0.13 | 916 |
| Mother Dtr | 24 | 10 | 16 | -0.03 | 0.02 | 0.01 | 234 |
| Mother Dtr | 24 | 10 | 32 | -0.10 | 0.04 | 0.02 | 840 |
| Silence | 24 | 10 | 16 | 0.05 | 0.09 | 0.06 | 159 |
| Silence | 24 | 10 | 32 | 0.08 | 0.26 | 0.11 | 580 |
| Coastguard | 48 | 10 | 16 | -0.01 | 0.04 | -0.11 | 150 |
| Coastguard | 48 | 10 | 32 | -0.03 | 0.18 | 0.11 | 544 |
| News | 48 | 7.5 | 16 | -0.01 | 0.28 | 0.23 | 202 |
| News | 48 | 7.5 | 32 | -0.06 | 0.25 | 0.19 | 751 |
| News | 112 | 15 | 16 | -0.11 | -0.04 | 0.01 | 258 |
| News | 112 | 15 | 32 | -0.09 | -0.02 | -0.02 | 970 |
| Foreman | 112 | 10 | 16 | -0.11 | 0.07 | 0.23 | 102 |
| Foreman | 112 | 10 | 32 | -0.18 | 0.13 | 0.32 | 369 |
| Coastguard | 112 | 10 | 16 | 0.08 | 0.25 | 0.2 | 118 |
| Coastguard | 112 | 10 | 32 | 0.13 | 0.26 | 0.21 | 452 |
| Foreman | 512 | 15 | 16 | -0.03 | 0.00 | 0.03 | 127 |
| Foreman | 512 | 15 | 32 | -0.07 | -0.04 | -0.01 | 474 |
| Foreman | 512 | 15 | 48 | -0.09 | -0.07 | -0.01 | 1010 |
| Foreman | 1024 | 30 | 16 | -0.06 | -0.05 | -0.04 | 169 |
| Foreman | 1024 | 30 | 32 | -0.06 | -0.07 | -0.06 | 634 |
| Foreman | 1024 | 30 | 48 | -0.07 | -0.06 | -0.04 | 1354 |
| Tennis | 1024 | 30 | 16 | -0.02 | -0.04 | -0.04 | 238 |
| Tennis | 1024 | 30 | 32 | -0.05 | -0.07 | -0.06 | 892 |
| Tennis | 1024 | 30 | 48 | -0.02 | -0.04 | -0.05 | 1893 |
| Tennis | 2048 | 30 | 16 | -0.01 | -0.03 | -0.03 | 267 |
| Tennis | 2048 | 30 | 32 | -0.03 | -0.03 | -0.03 | 1006 |
| Tennis | 2048 | 30 | 48 | -0.02 | -0.02 | -0.02 | 2133 |

| Sequence | Bitrate (kbps) | Frame Rate (fps) | Search Range | $\delta_{PSNR-Y}$ | $\delta_{PSNR-U}$ | $\delta_{PSNR-V}$ | COMPUTATIONAL GAIN |
|---|---|---|---|---|---|---|---|
| Bus | 4000 | 30 | 64 | -0.28 | -0.02 | -0.03 | 2218 |
| Bus | 4000 | 30 | 128 | -0.30 | 0.00 | 0 | 7872 |
| Bus | 9000 | 30 | 64 | -0.15 | 0.05 | 0.03 | 2375 |
| Bus | 9000 | 30 | 128 | -0.16 | 0.05 | 0.03 | 8420 |
| Basket Ball | 4000 | 30 | 64 | -0.25 | 0.05 | 0.03 | 1806 |
| Basket Ball | 4000 | 30 | 128 | -0.24 | 0.08 | 0.04 | 6477 |
| Basket Ball | 9000 | 30 | 64 | -0.24 | 0.00 | -0.01 | 1902 |
| Basket Ball | 9000 | 30 | 128 | -0.23 | 0.01 | -0.01 | 6821 |
| Cheerleader | 4000 | 30 | 64 | -0.12 | 0.06 | 0.12 | 1667 |
| Cheerleader | 4000 | 30 | 128 | -0.12 | 0.06 | 0.13 | 5894 |
| Cheerleader | 9000 | 30 | 64 | 0.00 | 0.1 | 0.14 | 1748 |
| Cheerleader | 9000 | 30 | 128 | 0.00 | 0.09 | 0.13 | 6191 |
| Stefan | 4000 | 30 | 64 | -0.33 | -0.05 | -0.04 | 2360 |
| Stefan | 4000 | 30 | 128 | -0.34 | -0.04 | -0.03 | 8349 |
| Stefan | 9000 | 30 | 64 | -0.18 | -0.06 | -0.05 | 2471 |
| Stefan | 9000 | 30 | 128 | -0.19 | -0.07 | -0.07 | 8744 |
| Flower Gdn. | 4000 | 30 | 64 | -0.15 | -0.06 | -0.02 | 2821 |
| Flower Gdn. | 4000 | 30 | 128 | -0.15 | -0.06 | -0.02 | 10024 |
| Flower Gdn. | 9000 | 30 | 64 | -0.13 | -0.05 | -0.03 | 2885 |
| Flower Gdn. | 9000 | 30 | 128 | -0.14 | -0.05 | -0.03 | 10238 |
| Bus Subs. 3:1 | 12000 | 30 | 128 | -0.48 | -0.01 | -0.07 | 6256 |
| Basket Subs. 3:1 | 12000 | 30 | 128 | -0.16 | 0.2 | 0.16 | 4647 |
| Stefan Subs. 3:1 | 12000 | 30 | 128 | -0.35 | -0.12 | -0.12 | 5646 |
| Flower Subs. 3:1 | 12000 | 30 | 128 | -0.29 | -0.11 | -0.07 | 7372 |

$\delta_{PSNR-Y}$ = (PSNR_Y for MVFAST ) – (PSNR_Y for FS)
$\delta_{PSNR-U}$ = (PSNR_U for MVFAST) – (PSNR_U for FS)
$\delta_{PSNR-V}$ = (PSNR_V for MVFAST) – (PSNR_V for FS)

| Container (10kbps , 7.5 fps) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Search Range=16 | | | | Search Range=32 | | | | | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| 72. | 30.70 | 29.78 | -0.93 | 232 | 30.31 | 29.40 | -0.90 | | | | |
| 192 | 29.86 | 29.21 | -0.65 | 192 | 29.57 | 28.88 | -0.69 | | | | |
| 176 | 29.53 | 28.87 | -0.65 | 220. | 29.52 | 28.84 | -0.68 | | | | |
| 172 | 29.73 | 29.10 | -0.63 | 240 | 29.30 | 28.67 | -0.63 | | | | |
| 52 | 30.43 | 29.81 | -0.62 | 236 | 29.65 | 29.04 | -0.61 | | | | |
| 216 | 29.50 | 28.90 | -0.60 | 224 | 29.65 | 29.04 | -0.61 | | | | |
| 180 | 29.67 | 29.14 | -0.53 | 260 | 29.55 | 29.01 | -0.54 | | | | |
| 196 | 29.24 | 28.74 | -0.50 | 212 | 29.56 | 29.10 | -0.46 | | | | |
| 200 | 29.70 | 29.21 | -0.49 | 80 | 30.14 | 29.74 | -0.40 | | | | |
| 64 | 30.38 | 29.94 | -0.45 | 228 | 29.12 | 28.73 | -0.39 | | | | |
| Hall Monitor (10kbps , 7.5 fps) | | | | | | | | | | | |
| Search Range=16 | | | | Search Range=32 | | | | | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| 276 | 31.12 | 30.14 | -0.97 | 112 | 29.75 | 29.09 | -0.66 | | | | |
| 180 | 30.61 | 29.78 | -0.83 | 164 | 30.62 | 29.99 | -0.63 | | | | |
| 124 | 30.53 | 29.74 | -0.79 | 152 | 30.47 | 29.84 | -0.63 | | | | |
| 112 | 29.79 | 29.03 | -0.76 | 72 | 29.96 | 29.42 | -0.53 | | | | |
| 116 | 30.24 | 29.56 | -0.68 | 212 | 30.38 | 29.85 | -0.53 | | | | |
| 68 | 29.97 | 29.36 | -0.61 | 292 | 30.64 | 30.25 | -0.39 | | | | |
| 100 | 29.67 | 29.08 | -0.60 | 104 | 29.46 | 29.12 | -0.34 | | | | |
| 132 | 30.68 | 30.25 | -0.43 | 116 | 29.89 | 29.56 | -0.33 | | | | |
| 224 | 30.12 | 29.78 | -0.34 | 88 | 29.57 | 29.26 | -0.32 | | | | |
| 160 | 30.50 | 30.18 | -0.31 | 96 | 29.35 | 29.04 | -0.31 | | | | |
| Mother-Daughter (24kbps , 10fps) | | | | | | | | | | | |
| Search Range=16 | | | | Search Range=32 | | | | | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| 156 | 33.08 | 32.74 | -0.34 | 60 | 34.52 | 34.12 | -0.40 | | | | |
| 192 | 33.84 | 33.53 | -0.31 | 45 | 35.60 | 35.22 | -0.38 | | | | |
| 198 | 33.82 | 33.54 | -0.28 | 63 | 33.44 | 33.10 | -0.34 | | | | |
| 51 | 34.81 | 34.56 | -0.25 | 183 | 35.18 | 34.84 | -0.34 | | | | |
| 162 | 33.52 | 33.29 | -0.23 | 162 | 33.51 | 33.18 | -0.33 | | | | |
| 129 | 34.05 | 33.82 | -0.23 | 171 | 34.33 | 34.01 | -0.32 | | | | |
| 252 | 36.57 | 36.35 | -0.21 | 267 | 35.38 | 35.06 | -0.31 | | | | |
| 135 | 33.73 | 33.52 | -0.21 | 261 | 35.38 | 35.07 | -0.31 | | | | |
| 48 | 35.13 | 34.94 | -0.19 | 48 | 35.05 | 34.77 | -0.29 | | | | |
| 186 | 34.93 | 34.75 | -0.17 | 255 | 36.56 | 36.29 | -0.28 | | | | |

| Silent (24kbps , 10 fps) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Search Range=16 | | | | Search Range=32 | | | | | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| 144 | 31.56 | 30.49 | -1.06 | 156 | 31.46 | 30.66 | -0.80 | | | | |
| 156 | 31.54 | 30.69 | -0.85 | 33 | 30.80 | 30.37 | -0.43 | | | | |
| 162 | 31.33 | 30.82 | -0.51 | 168 | 31.11 | 30.68 | -0.42 | | | | |
| 150 | 32.28 | 31.91 | -0.37 | 51 | 30.54 | 30.14 | -0.40 | | | | |
| 204 | 30.26 | 29.92 | -0.34 | 162 | 31.24 | 30.90 | -0.34 | | | | |
| 99 | 31.67 | 31.42 | -0.24 | 141 | 31.76 | 31.46 | -0.30 | | | | |
| 87 | 30.70 | 30.48 | -0.22 | 63 | 30.89 | 30.59 | -0.30 | | | | |
| 105 | 31.90 | 31.68 | -0.22 | 150 | 32.14 | 31.87 | -0.28 | | | | |
| 21 | 30.28 | 30.06 | -0.22 | 75 | 30.34 | 30.11 | -0.23 | | | | |
| 198 | 30.55 | 30.33 | -0.22 | 108 | 31.49 | 31.28 | -0.21 | | | | |
| Coastguard(48kbps , 10 fps) | | | | | | | | | | | |
| Search Range=16 | | | | Search Range=32 | | | | | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| 294 | 30.22 | 29.67 | -0.55 | 294 | 30.31 | 29.79 | -0.53 | | | | |
| 288 | 30.08 | 29.66 | -0.41 | 282 | 30.24 | 29.75 | -0.49 | | | | |
| 282 | 30.14 | 29.75 | -0.38 | 276 | 29.95 | 29.54 | -0.41 | | | | |
| 252 | 29.73 | 29.51 | -0.22 | 288 | 30.04 | 29.70 | -0.34 | | | | |
| 249 | 29.74 | 29.53 | -0.22 | 198 | 29.08 | 28.81 | -0.26 | | | | |
| 162 | 28.77 | 28.57 | -0.21 | 201 | 29.17 | 28.91 | -0.26 | | | | |
| 243 | 29.83 | 29.63 | -0.20 | 210 | 29.63 | 29.43 | -0.20 | | | | |
| 228 | 29.74 | 29.55 | -0.20 | 192 | 29.11 | 28.91 | -0.20 | | | | |
| 201 | 29.17 | 28.98 | -0.19 | 174 | 28.19 | 28.00 | -0.19 | | | | |
| 240 | 29.74 | 29.57 | -0.17 | 213 | 29.28 | 29.11 | -0.18 | | | | |
| News (48kbps , 7.5fps) | | | | | | | | | | | |
| Search Range=16 | | | | Search Range=32 | | | | | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| 52 | 33.73 | 32.45 | -1.28 | 80 | 32.78 | 31.41 | -1.37 | | | | |
| 28 | 32.80 | 31.58 | -1.22 | 72 | 33.19 | 31.84 | -1.35 | | | | |
| 148 | 32.29 | 31.09 | -1.20 | 28 | 32.87 | 31.61 | -1.26 | | | | |
| 20 | 32.78 | 31.70 | -1.09 | 20 | 32.87 | 31.69 | -1.18 | | | | |
| 68 | 33.48 | 32.39 | -1.09 | 44 | 33.17 | 32.12 | -1.05 | | | | |
| 76 | 32.77 | 31.70 | -1.07 | 36 | 32.98 | 31.96 | -1.02 | | | | |
| 60 | 33.40 | 32.34 | -1.07 | 144 | 32.32 | 31.32 | -1.01 | | | | |
| 44 | 33.30 | 32.25 | -1.06 | 64 | 33.17 | 32.31 | -0.86 | | | | |
| 132 | 32.00 | 30.97 | -1.03 | 12 | 32.18 | 31.40 | -0.78 | | | | |
| 124 | 32.43 | 31.48 | -0.95 | 296 | 32.62 | 31.86 | -0.76 | | | | |

| News (112kbps , 15 fps) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Search Range=16 | | | | Search Range=32 | | | | | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| 126 | 35.51 | 33.07 | -2.44 | 130 | 34.71 | 32.20 | -2.51 | | | | |
| 130 | 34.58 | 32.32 | -2.26 | 292 | 35.17 | 33.29 | -1.88 | | | | |
| 122 | 35.10 | 33.18 | -1.92 | 288 | 35.24 | 33.51 | -1.73 | | | | |
| 292 | 35.00 | 33.23 | -1.77 | 126 | 34.60 | 33.02 | -1.58 | | | | |
| 118 | 34.68 | 33.26 | -1.43 | 134 | 34.38 | 32.95 | -1.43 | | | | |
| 262 | 34.45 | 33.36 | -1.09 | 146 | 34.09 | 32.68 | -1.41 | | | | |
| 260 | 33.58 | 32.55 | -1.03 | 122 | 34.25 | 33.11 | -1.14 | | | | |
| 284 | 34.72 | 33.73 | -0.99 | 260 | 34.78 | 33.66 | -1.12 | | | | |
| 296 | 34.57 | 33.59 | -0.98 | 296 | 34.82 | 33.78 | -1.04 | | | | |
| 134 | 34.38 | 33.48 | -0.90 | 284 | 34.87 | 33.87 | -1.00 | | | | |
| Foreman (112kbps , 10fps) | | | | | | | | | | | |
| Search Range=16 | | | | Search Range=32 | | | | | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| 147 | 31.96 | 31.03 | -0.92 | 147 | 31.75 | 30.30 | -1.45 | | | | |
| 129 | 31.43 | 30.70 | -0.73 | 66 | 32.01 | 30.80 | -1.21 | | | | |
| 153 | 32.17 | 31.56 | -0.62 | 153 | 32.20 | 31.04 | -1.17 | | | | |
| 60 | 31.25 | 30.64 | -0.61 | 78 | 32.19 | 31.04 | -1.14 | | | | |
| 105 | 32.79 | 32.21 | -0.58 | 72 | 31.88 | 30.88 | -1.00 | | | | |
| 21 | 31.41 | 30.83 | -0.58 | 60 | 31.33 | 30.61 | -0.73 | | | | |
| 57 | 31.87 | 31.29 | -0.58 | 57 | 32.07 | 31.35 | -0.72 | | | | |
| 102 | 32.58 | 32.00 | -0.58 | 48 | 32.26 | 31.59 | -0.67 | | | | |
| 123 | 33.51 | 32.93 | -0.58 | 93 | 31.44 | 30.83 | -0.62 | | | | |
| 84 | 30.56 | 29.98 | -0.57 | 108 | 33.08 | 32.47 | -0.61 | | | | |
| Coastguard (112kbps , 10fps) | | | | | | | | | | | |
| Search Range=16 | | | | Search Range=32 | | | | | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| 279 | 27.65 | 27.33 | -0.32 | 168 | 27.00 | 26.75 | -0.25 | | | | |
| 255 | 27.76 | 27.46 | -0.30 | 273 | 27.39 | 27.19 | -0.20 | | | | |
| 267 | 27.55 | 27.34 | -0.21 | 279 | 27.54 | 27.36 | -0.18 | | | | |
| 273 | 27.47 | 27.27 | -0.20 | 114 | 27.12 | 26.96 | -0.16 | | | | |
| 249 | 27.60 | 27.44 | -0.16 | 174 | 26.87 | 26.73 | -0.14 | | | | |
| 261 | 27.63 | 27.53 | -0.10 | 285 | 27.49 | 27.36 | -0.13 | | | | |
| 258 | 27.66 | 27.56 | -0.09 | 6 | 27.34 | 27.24 | -0.11 | | | | |
| 21 | 27.40 | 27.31 | -0.09 | 21 | 27.43 | 27.33 | -0.10 | | | | |
| 3 | 28.41 | 28.33 | -0.09 | 3 | 28.42 | 28.33 | -0.09 | | | | |
| 126 | 26.56 | 26.48 | -0.08 | 291 | 27.60 | 27.53 | -0.08 | | | | |

| Foreman (512kbps , 15 fps) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Search Range=16 | | | | Search Range=32 | | | | Search Range=48 | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ |
| 76 | 36.02 | 35.78 | -0.24 | 194 | 34.65 | 34.13 | -0.52 | 198 | 36.30 | 35.61 | -0.69 |
| 210 | 35.68 | 35.47 | -0.21 | 196 | 34.73 | 34.23 | -0.50 | 194 | 35.80 | 35.17 | -0.64 |
| 80 | 35.01 | 34.81 | -0.20 | 198 | 35.84 | 35.34 | -0.49 | 196 | 35.33 | 34.72 | -0.62 |
| 180 | 37.65 | 37.45 | -0.20 | 192 | 34.47 | 34.10 | -0.37 | 214 | 35.92 | 35.32 | -0.61 |
| 78 | 35.48 | 35.29 | -0.19 | 180 | 37.90 | 37.54 | -0.36 | 192 | 36.32 | 35.72 | -0.59 |
| 64 | 35.77 | 35.60 | -0.17 | 200 | 36.98 | 36.66 | -0.32 | 216 | 35.23 | 34.69 | -0.54 |
| 160 | 34.42 | 34.24 | -0.17 | 140 | 34.67 | 34.35 | -0.32 | 200 | 37.17 | 36.77 | -0.40 |
| 36 | 35.97 | 35.81 | -0.17 | 216 | 35.25 | 34.98 | -0.27 | 218 | 33.63 | 33.25 | -0.37 |
| 124 | 36.38 | 36.21 | -0.17 | 76 | 36.03 | 35.78 | -0.26 | 180 | 37.93 | 37.57 | -0.35 |
| 150 | 37.49 | 37.33 | -0.17 | 214 | 35.91 | 35.65 | -0.25 | 212 | 36.11 | 35.77 | -0.34 |
| Foreman (1024kbps , 30 fps) | | | | | | | | | | | |
| Search Range=16 | | | | Search Range=32 | | | | Search Range=48 | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ |
| 212 | 37.15 | 36.68 | -0.48 | 212 | 37.16 | 36.71 | -0.45 | 204 | 38.45 | 38.03 | -0.43 |
| 204 | 38.22 | 37.75 | -0.47 | 210 | 38.34 | 37.92 | -0.42 | 213 | 37.26 | 36.85 | -0.41 |
| 213 | 37.30 | 36.85 | -0.45 | 201 | 38.42 | 38.02 | -0.40 | 212 | 37.14 | 36.76 | -0.39 |
| 211 | 37.38 | 36.99 | -0.39 | 211 | 37.43 | 37.05 | -0.38 | 206 | 38.52 | 38.14 | -0.38 |
| 205 | 38.25 | 37.88 | -0.37 | 213 | 37.22 | 36.84 | -0.38 | 205 | 38.36 | 37.98 | -0.37 |
| 206 | 38.40 | 38.08 | -0.33 | 206 | 38.53 | 38.17 | -0.36 | 201 | 38.39 | 38.02 | -0.37 |
| 209 | 38.23 | 37.90 | -0.33 | 214 | 37.28 | 36.93 | -0.35 | 190 | 38.65 | 38.30 | -0.36 |
| 203 | 38.15 | 37.83 | -0.32 | 205 | 38.37 | 38.03 | -0.34 | 198 | 37.80 | 37.46 | -0.34 |
| 210 | 38.21 | 37.90 | -0.30 | 188 | 39.27 | 38.93 | -0.34 | 211 | 37.42 | 37.08 | -0.34 |
| 208 | 38.63 | 38.33 | -0.30 | 198 | 37.78 | 37.45 | -0.33 | 210 | 38.33 | 38.00 | -0.33 |
| Table Tennis (1024kbps , 30fps) | | | | | | | | | | | |
| Search Range=16 | | | | Search Range=32 | | | | Search Range=48 | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ |
| 101 | 33.30 | 32.97 | -0.33 | 210 | 36.02 | 35.53 | -0.49 | 84 | 32.52 | 32.17 | -0.35 |
| 98 | 33.35 | 33.05 | -0.30 | 88 | 32.41 | 32.05 | -0.37 | 64 | 34.72 | 34.39 | -0.34 |
| 55 | 34.63 | 34.34 | -0.30 | 241 | 36.58 | 36.24 | -0.34 | 94 | 33.41 | 33.10 | -0.31 |
| 57 | 34.52 | 34.24 | -0.29 | 211 | 35.81 | 35.48 | -0.33 | 45 | 37.86 | 37.55 | -0.30 |
| 93 | 33.24 | 32.96 | -0.27 | 102 | 33.30 | 32.97 | -0.32 | 89 | 32.66 | 32.37 | -0.28 |
| 104 | 33.05 | 32.80 | -0.26 | 240 | 36.82 | 36.51 | -0.31 | 62 | 35.15 | 34.88 | -0.27 |
| 82 | 32.64 | 32.41 | -0.23 | 90 | 33.60 | 33.30 | -0.30 | 57 | 34.49 | 34.22 | -0.27 |
| 64 | 34.73 | 34.51 | -0.22 | 56 | 34.57 | 34.28 | -0.30 | 63 | 34.96 | 34.70 | -0.26 |
| 62 | 35.17 | 34.95 | -0.22 | 242 | 36.59 | 36.31 | -0.28 | 93 | 33.17 | 32.91 | -0.26 |
| 67 | 34.20 | 33.98 | -0.22 | 68 | 34.20 | 33.93 | -0.27 | 106 | 33.40 | 33.16 | -0.24 |

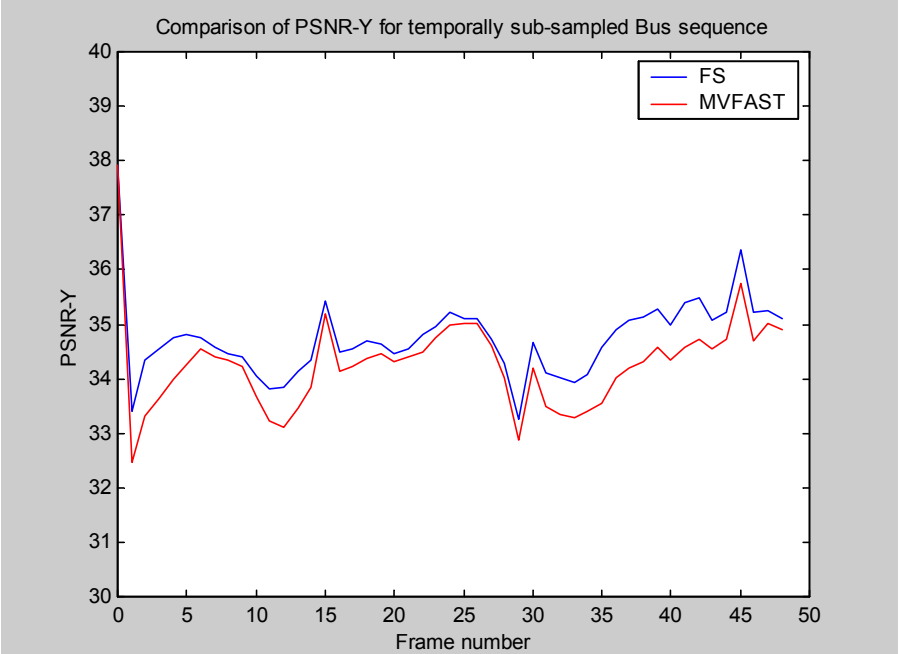
| Table Tennis (2048kbps , 30 fps) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Search Range=16 | | | | Search Range=32 | | | | Search Range=48 | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ |
| 89 | 36.27 | 36.02 | -0.24 | 91 | 36.70 | 36.46 | -0.24 | 88 | 35.90 | 35.64 | -0.25 |
| 85 | 36.05 | 35.84 | -0.21 | 53 | 38.01 | 37.78 | -0.23 | 84 | 35.99 | 35.77 | -0.22 |
| 59 | 37.68 | 37.50 | -0.19 | 59 | 37.68 | 37.46 | -0.22 | 89 | 36.21 | 35.99 | -0.22 |
| 84 | 36.06 | 35.88 | -0.18 | 66 | 37.39 | 37.18 | -0.21 | 91 | 36.69 | 36.47 | -0.22 |
| 66 | 37.43 | 37.25 | -0.18 | 64 | 37.75 | 37.54 | -0.21 | 64 | 37.74 | 37.52 | -0.22 |
| 94 | 36.72 | 36.54 | -0.18 | 63 | 37.99 | 37.79 | -0.20 | 180 | 39.15 | 38.95 | -0.21 |
| 67 | 37.25 | 37.09 | -0.17 | 67 | 37.26 | 37.07 | -0.19 | 44 | 37.97 | 37.77 | -0.21 |
| 88 | 35.86 | 35.70 | -0.16 | 65 | 37.48 | 37.29 | -0.19 | 43 | 38.05 | 37.86 | -0.20 |
| 53 | 37.92 | 37.77 | -0.16 | 57 | 37.71 | 37.52 | -0.19 | 65 | 37.47 | 37.28 | -0.19 |
| 38 | 37.97 | 37.82 | -0.15 | 44 | 37.97 | 37.79 | -0.18 | 63 | 37.96 | 37.77 | -0.19 |
| Bus (4000kbps , 30 fps) | | | | | | | | | | | |
| Search Range=64 | | | | Search Range=128 | | | | | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| 116 | 29.98 | 29.34 | -0.63 | 5 | 29.51 | 28.82 | -0.69 | | | | |
| 118 | 30.16 | 29.54 | -0.62 | 119 | 30.23 | 29.55 | -0.67 | | | | |
| 10 | 29.33 | 28.72 | -0.62 | 6 | 29.41 | 28.74 | -0.67 | | | | |
| 5 | 29.46 | 28.85 | -0.61 | 4 | 29.58 | 28.91 | -0.67 | | | | |
| 113 | 29.98 | 29.38 | -0.60 | 116 | 29.96 | 29.30 | -0.67 | | | | |
| 115 | 30.02 | 29.43 | -0.59 | 117 | 30.15 | 29.48 | -0.66 | | | | |
| 117 | 30.14 | 29.55 | -0.59 | 8 | 29.27 | 28.62 | -0.65 | | | | |
| 4 | 29.54 | 28.96 | -0.58 | 118 | 30.13 | 29.48 | -0.65 | | | | |
| 114 | 29.95 | 29.38 | -0.57 | 7 | 29.34 | 28.70 | -0.64 | | | | |
| 122 | 30.38 | 29.81 | -0.57 | 115 | 30.02 | 29.39 | -0.63 | | | | |
| Bus (9000kbps , 30fps) | | | | | | | | | | | |
| Search Range=64 | | | | Search Range=128 | | | | | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| 1 | 33.48 | 32.85 | -0.63 | 1 | 33.48 | 32.85 | -0.64 | | | | |
| 2 | 33.79 | 33.29 | -0.50 | 2 | 33.81 | 33.28 | -0.54 | | | | |
| 3 | 33.75 | 33.35 | -0.40 | 3 | 33.82 | 33.34 | -0.48 | | | | |
| 4 | 33.68 | 33.31 | -0.37 | 125 | 34.24 | 33.79 | -0.45 | | | | |
| 118 | 34.37 | 34.01 | -0.35 | 4 | 33.73 | 33.29 | -0.44 | | | | |
| 119 | 34.43 | 34.08 | -0.35 | 118 | 34.35 | 33.96 | -0.39 | | | | |
| 8 | 33.49 | 33.15 | -0.34 | 124 | 34.24 | 33.88 | -0.37 | | | | |
| 117 | 34.39 | 34.06 | -0.34 | 6 | 33.59 | 33.23 | -0.36 | | | | |
| 5 | 33.64 | 33.31 | -0.33 | 5 | 33.65 | 33.30 | -0.36 | | | | |
| 125 | 34.28 | 33.95 | -0.33 | 119 | 34.38 | 34.03 | -0.35 | | | | |

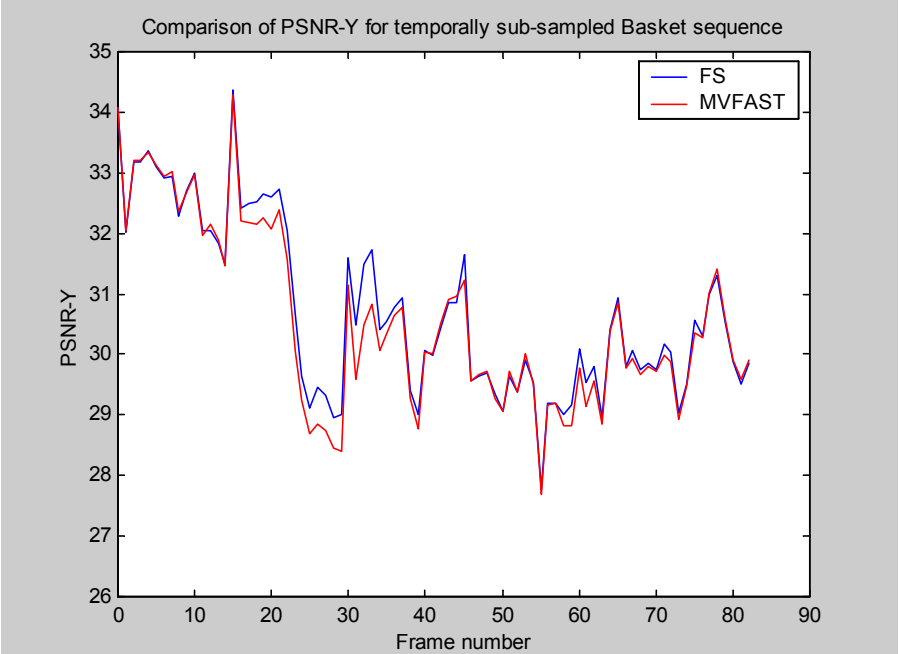
| Basketball (4000kbps , 30 fps) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Search Range=64 | | | | Search Range=128 | | | | | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| 53 | 28.91 | 28.03 | -0.88 | 52 | 28.87 | 28.03 | -0.84 | | | | |
| 52 | 28.88 | 28.01 | -0.88 | 53 | 28.86 | 28.08 | -0.78 | | | | |
| 54 | 28.74 | 28.02 | -0.72 | 51 | 28.83 | 28.13 | -0.70 | | | | |
| 51 | 28.85 | 28.13 | -0.72 | 81 | 25.59 | 24.91 | -0.68 | | | | |
| 85 | 25.54 | 24.88 | -0.66 | 83 | 25.40 | 24.72 | -0.67 | | | | |
| 83 | 25.36 | 24.71 | -0.65 | 54 | 28.76 | 28.09 | -0.67 | | | | |
| 55 | 28.66 | 28.01 | -0.65 | 82 | 25.29 | 24.63 | -0.66 | | | | |
| 81 | 25.58 | 24.95 | -0.64 | 85 | 25.49 | 24.83 | -0.66 | | | | |
| 84 | 25.38 | 24.74 | -0.64 | 55 | 28.69 | 28.03 | -0.66 | | | | |
| 86 | 25.63 | 24.99 | -0.64 | 56 | 28.84 | 28.23 | -0.61 | | | | |
| Baketball (9000kbps , 30fps) | | | | | | | | | | | |
| Search Range=64 | | | | Search Range=128 | | | | | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| 81 | 29.56 | 28.55 | -1.00 | 81 | 29.54 | 28.53 | -1.01 | | | | |
| 52 | 33.60 | 32.62 | -0.98 | 52 | 33.62 | 32.61 | -1.00 | | | | |
| 163 | 29.44 | 28.52 | -0.92 | 82 | 29.23 | 28.27 | -0.95 | | | | |
| 82 | 29.24 | 28.32 | -0.92 | 51 | 33.52 | 32.57 | -0.95 | | | | |
| 51 | 33.53 | 32.62 | -0.91 | 83 | 29.26 | 28.35 | -0.90 | | | | |
| 53 | 33.63 | 32.75 | -0.88 | 49 | 32.85 | 31.96 | -0.89 | | | | |
| 80 | 29.84 | 28.98 | -0.87 | 84 | 29.25 | 28.39 | -0.85 | | | | |
| 49 | 32.89 | 32.02 | -0.87 | 80 | 29.79 | 28.94 | -0.85 | | | | |
| 164 | 27.95 | 27.09 | -0.86 | 163 | 29.45 | 28.60 | -0.85 | | | | |
| 84 | 29.28 | 28.45 | -0.83 | 50 | 33.42 | 32.57 | -0.84 | | | | |
| Cheerleader (4000kbps , 30 fps) | | | | | | | | | | | |
| Search Range=64 | | | | Search Range=128 | | | | | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| 60 | 30.41 | 30.04 | -0.37 | 60 | 30.36 | 30.01 | -0.35 | | | | |
| 75 | 30.37 | 30.01 | -0.36 | 75 | 30.31 | 29.98 | -0.33 | | | | |
| 120 | 30.85 | 30.59 | -0.26 | 30 | 30.97 | 30.65 | -0.31 | | | | |
| 30 | 30.95 | 30.69 | -0.26 | 50 | 28.53 | 28.26 | -0.28 | | | | |
| 45 | 30.40 | 30.14 | -0.26 | 45 | 30.39 | 30.13 | -0.26 | | | | |
| 105 | 30.91 | 30.65 | -0.26 | 61 | 29.27 | 29.01 | -0.26 | | | | |
| 61 | 29.28 | 29.03 | -0.25 | 62 | 29.09 | 28.85 | -0.24 | | | | |
| 90 | 31.01 | 30.77 | -0.24 | 120 | 30.86 | 30.63 | -0.24 | | | | |
| 135 | 30.77 | 30.54 | -0.23 | 90 | 30.94 | 30.72 | -0.22 | | | | |
| 50 | 28.54 | 28.32 | -0.21 | 99 | 29.43 | 29.21 | -0.22 | | | | |

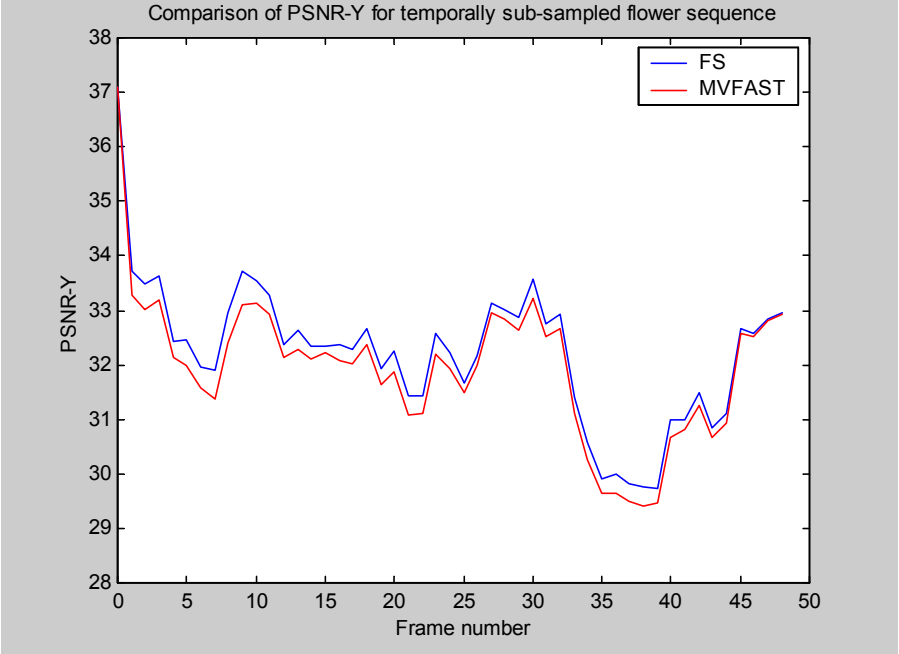
| Cheerleader (9000kbps , 30fps) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Search Range=64 | | | | Search Range=128 | | | | | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| 60 | 34.53 | 34.34 | -0.20 | 105 | 35.04 | 34.85 | -0.19 | | | | |
| 105 | 35.05 | 34.88 | -0.17 | 90 | 35.25 | 35.09 | -0.16 | | | | |
| 45 | 34.38 | 34.22 | -0.16 | 30 | 35.30 | 35.15 | -0.15 | | | | |
| 30 | 35.31 | 35.17 | -0.15 | 45 | 34.38 | 34.23 | -0.15 | | | | |
| 96 | 34.16 | 34.02 | -0.14 | 60 | 34.51 | 34.37 | -0.14 | | | | |
| 46 | 33.15 | 33.02 | -0.13 | 15 | 35.86 | 35.73 | -0.13 | | | | |
| 120 | 35.25 | 35.12 | -0.12 | 98 | 33.94 | 33.81 | -0.13 | | | | |
| 15 | 35.86 | 35.74 | -0.12 | 48 | 33.06 | 32.94 | -0.12 | | | | |
| 135 | 35.05 | 34.94 | -0.11 | 135 | 35.06 | 34.94 | -0.12 | | | | |
| 86 | 33.56 | 33.45 | -0.11 | 34 | 33.20 | 33.09 | -0.10 | | | | |
| Stefan (4000kbps , 30 fps) | | | | | | | | | | | |
| Search Range=64 | | | | Search Range=128 | | | | | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| 266 | 29.62 | 28.22 | -1.39 | 12 | 30.46 | 29.01 | -1.45 | | | | |
| 267 | 29.25 | 27.89 | -1.37 | 11 | 30.60 | 29.22 | -1.38 | | | | |
| 265 | 29.66 | 28.31 | -1.34 | 183 | 31.03 | 29.79 | -1.24 | | | | |
| 184 | 30.70 | 29.38 | -1.32 | 184 | 30.76 | 29.54 | -1.22 | | | | |
| 183 | 30.98 | 29.69 | -1.29 | 182 | 31.26 | 30.05 | -1.21 | | | | |
| 268 | 29.05 | 27.78 | -1.27 | 249 | 30.01 | 28.81 | -1.20 | | | | |
| 11 | 30.56 | 29.31 | -1.25 | 181 | 31.39 | 30.20 | -1.19 | | | | |
| 10 | 30.78 | 29.54 | -1.23 | 266 | 29.60 | 28.42 | -1.18 | | | | |
| 185 | 30.42 | 29.24 | -1.18 | 250 | 29.88 | 28.73 | -1.14 | | | | |
| 269 | 28.80 | 27.63 | -1.17 | 10 | 30.71 | 29.58 | -1.14 | | | | |
| Stefan (9000kbps , 30fps) | | | | | | | | | | | |
| Search Range=64 | | | | Search Range=128 | | | | | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| 11 | 34.90 | 33.84 | -1.06 | 11 | 34.88 | 33.82 | -1.06 | | | | |
| 10 | 35.05 | 34.04 | -1.01 | 251 | 34.80 | 33.75 | -1.04 | | | | |
| 299 | 30.53 | 29.52 | -1.01 | 250 | 34.81 | 33.78 | -1.03 | | | | |
| 246 | 34.72 | 33.87 | -0.85 | 10 | 35.03 | 34.03 | -1.00 | | | | |
| 298 | 30.75 | 29.90 | -0.84 | 249 | 34.98 | 33.98 | -0.99 | | | | |
| 249 | 34.95 | 34.14 | -0.80 | 299 | 30.56 | 29.60 | -0.96 | | | | |
| 9 | 35.07 | 34.27 | -0.80 | 248 | 34.83 | 33.88 | -0.95 | | | | |
| 266 | 34.22 | 33.42 | -0.80 | 247 | 34.81 | 33.90 | -0.91 | | | | |
| 267 | 33.93 | 33.15 | -0.78 | 264 | 34.45 | 33.55 | -0.90 | | | | |
| 248 | 34.79 | 34.01 | -0.78 | 246 | 34.77 | 33.88 | -0.89 | | | | |

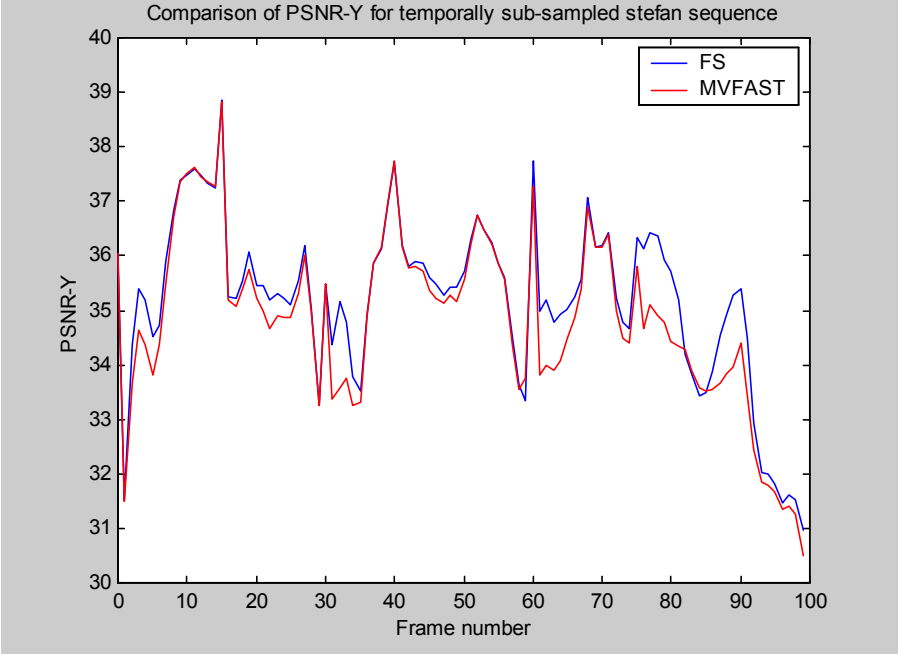
| Flower Garden (4000kbps , 30 fps) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Search Range=64 | | | | Search Range=128 | | | | | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| 16 | 29.26 | 28.71 | -0.55 | 14 | 27.44 | 26.97 | -0.47 | | | | |
| 14 | 27.46 | 26.96 | -0.50 | 16 | 29.17 | 28.71 | -0.45 | | | | |
| 13 | 27.03 | 26.56 | -0.47 | 2 | 30.20 | 29.76 | -0.45 | | | | |
| 15 | 30.00 | 29.54 | -0.46 | 12 | 27.45 | 27.01 | -0.44 | | | | |
| 2 | 30.22 | 29.77 | -0.45 | 13 | 26.96 | 26.54 | -0.43 | | | | |
| 12 | 27.48 | 27.04 | -0.44 | 11 | 28.20 | 27.81 | -0.38 | | | | |
| 9 | 29.51 | 29.12 | -0.39 | 9 | 29.50 | 29.11 | -0.38 | | | | |
| 7 | 29.21 | 28.83 | -0.38 | 3 | 30.28 | 29.93 | -0.35 | | | | |
| 11 | 28.21 | 27.84 | -0.38 | 10 | 29.14 | 28.79 | -0.35 | | | | |
| 17 | 28.74 | 28.37 | -0.37 | 8 | 29.22 | 28.88 | -0.34 | | | | |
| Flower Garden (9000kbps , 30fps) | | | | | | | | | | | |
| Search Range=64 | | | | Search Range=128 | | | | | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | |
| 14 | 32.92 | 32.39 | -0.54 | 21 | 33.50 | 32.97 | -0.53 | | | | |
| 21 | 33.50 | 32.98 | -0.52 | 22 | 33.88 | 33.36 | -0.52 | | | | |
| 22 | 33.89 | 33.37 | -0.52 | 14 | 32.91 | 32.39 | -0.52 | | | | |
| 20 | 32.73 | 32.25 | -0.48 | 20 | 32.72 | 32.24 | -0.48 | | | | |
| 2 | 34.64 | 34.17 | -0.47 | 2 | 34.63 | 34.16 | -0.47 | | | | |
| 16 | 34.01 | 33.57 | -0.45 | 16 | 34.01 | 33.56 | -0.45 | | | | |
| 23 | 33.80 | 33.36 | -0.44 | 23 | 33.79 | 33.35 | -0.44 | | | | |
| 13 | 32.06 | 31.63 | -0.43 | 19 | 31.79 | 31.35 | -0.43 | | | | |
| 17 | 33.44 | 33.02 | -0.42 | 17 | 33.42 | 33.01 | -0.42 | | | | |
| 19 | 31.78 | 31.37 | -0.41 | 24 | 34.02 | 33.62 | -0.40 | | | | |
| Bus Subsampled at 3:1 (12000kbps , 30 fps) | | | | | | | | | | | |
| Search Range=128 | | | | | | | | | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | | | | | |
| 2 | 34.35 | 33.31 | -1.05 | | | | | | | | |
| 35 | 34.56 | 33.55 | -1.01 | | | | | | | | |
| 1 | 33.39 | 32.46 | -0.93 | | | | | | | | |
| 3 | 34.56 | 33.64 | -0.92 | | | | | | | | |
| 36 | 34.90 | 34.01 | -0.90 | | | | | | | | |
| 37 | 35.07 | 34.21 | -0.87 | | | | | | | | |
| 41 | 35.39 | 34.57 | -0.81 | | | | | | | | |
| 38 | 35.12 | 34.32 | -0.80 | | | | | | | | |
| 4 | 34.76 | 34.00 | -0.76 | | | | | | | | |
| 42 | 35.48 | 34.73 | -0.75 | | | | | | | | |

| Basket Subsampled at 3:1 (12000kbps , 30fps) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Search Range=128 | | | | | | | | | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | | | | | |
| 32 | 31.48 | 30.48 | -1.00 | | | | | | | | |
| 31 | 30.48 | 29.59 | -0.89 | | | | | | | | |
| 33 | 31.72 | 30.83 | -0.88 | | | | | | | | |
| 29 | 29.02 | 28.40 | -0.61 | | | | | | | | |
| 26 | 29.45 | 28.84 | -0.61 | | | | | | | | |
| 23 | 30.67 | 30.07 | -0.60 | | | | | | | | |
| 27 | 29.33 | 28.74 | -0.59 | | | | | | | | |
| 20 | 32.61 | 32.07 | -0.54 | | | | | | | | |
| 28 | 28.96 | 28.45 | -0.52 | | | | | | | | |
| 22 | 32.04 | 31.56 | -0.48 | | | | | | | | |
| Stefan Subsampled at 3:1 (12000kbps , 30 fps) | | | | | | | | | | | |
| Search Range=128 | | | | | | | | | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | | | | | |
| 32 | 35.17 | 33.58 | -1.59 | | | | | | | | |
| 78 | 36.35 | 34.88 | -1.47 | | | | | | | | |
| 76 | 36.13 | 34.68 | -1.45 | | | | | | | | |
| 89 | 35.28 | 33.95 | -1.33 | | | | | | | | |
| 77 | 36.41 | 35.09 | -1.33 | | | | | | | | |
| 80 | 35.71 | 34.42 | -1.28 | | | | | | | | |
| 62 | 35.20 | 33.98 | -1.22 | | | | | | | | |
| 61 | 35.00 | 33.81 | -1.19 | | | | | | | | |
| 79 | 35.91 | 34.79 | -1.12 | | | | | | | | |
| 88 | 34.92 | 33.85 | -1.07 | | | | | | | | |
| Flower subsampled at 3:1 (12000kbps , 30fps) | | | | | | | | | | | |
| Search Range=128 | | | | | | | | | | | |
| Frame No. | PSNR-Y (FS) | PSNR-Y (MVFAST) | $\delta_{PSNR-Y}$ | | | | | | | | |
| 9 | 33.73 | 33.09 | -0.64 | | | | | | | | |
| 8 | 32.95 | 32.40 | -0.55 | | | | | | | | |
| 7 | 31.90 | 31.36 | -0.54 | | | | | | | | |
| 5 | 32.47 | 31.99 | -0.49 | | | | | | | | |
| 2 | 33.50 | 33.02 | -0.48 | | | | | | | | |
| 3 | 33.62 | 33.18 | -0.44 | | | | | | | | |
| 1 | 33.71 | 33.29 | -0.43 | | | | | | | | |
| 10 | 33.54 | 33.14 | -0.40 | | | | | | | | |
| 20 | 32.24 | 31.86 | -0.38 | | | | | | | | |
| 23 | 32.57 | 32.20 | -0.38 | | | | | | | | |


Comparison of PSNR-Y for temporally sub-sampled Bus sequence
PSNR-Y
Frame number
FS
MVFAST


Comparison of PSNR-Y for temporally sub-sampled Basket sequence
PSNR-Y
Frame number
FS
MVFAST


Comparison of PSNR-Y for temporally sub-sampled flower sequence
PSNR-Y
Frame number
FS
MVFAST


Comparison of PSNR-Y for temporally sub-sampled stefan sequence
PSNR-Y
Frame number
FS
MVFAST