RATE DISTORTION-BASED MOTION ESTIMATION SEARCH ORDERING FOR RATE-CONSTRAINED SUCCESSIVE ELIMINATION ALGORITHMS

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INTRODUCTION AND PROBLEM STATEMENT

- Motion estimation is a predominant task of most modern video encoders.
- Successive elimination algorithms (SEA) rely on known inequalities - to avoid computing the cost of candidate blocks during the search process.
- Search orderings, such as raster and spiral search, **can impair the filtering criterion** of rate-constrained successive elimination algorithms.

STATE OF THE ART APPROACHES

- Rate-Constraint Successive Elimination Algorithm

$$\left|B - C(\mathbf{x}_i, \mathbf{y}_i)\right| \le SAD(\mathbf{x}^*_{i-1}, \mathbf{y}^*_{i-1}) + \lambda R(\mathbf{x}^*_{i-1}, \mathbf{y}^*_{i-1}) - \lambda R(\mathbf{x}_i, \mathbf{y}_i)$$

- When $\lambda R(\mathbf{x}^*_{i-1}, \mathbf{y}^*_{i-1}) > \lambda R(\mathbf{x}_i, \mathbf{y}_i)$, this will increase the filtering threshold and thus **weaken the filtering criterion**.

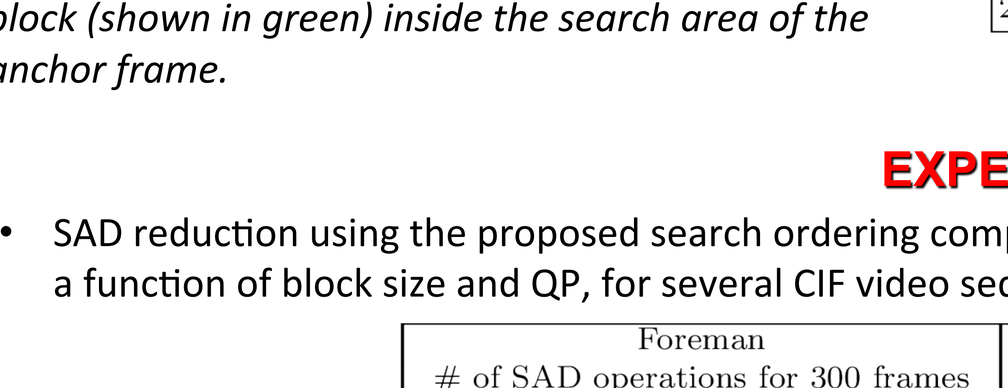

Illustration of motion estimation elements. The current block (shown in red) is predicted using a candidate block (shown in green) inside the search area of the anchor frame.

THE PROPOSED APPROACH

- **We propose a new class of search orderings** known as rate-constrained search orderings. To be classified as such, the search ordering must adhere to the following rule

$$R(\mathbf{x}_i, \mathbf{y}_i) \ge R(\mathbf{x}_{i-1}, \mathbf{y}_{i-1})$$

- Values in the following tables show the evaluation order of a subset of candidate blocks (from 0 to 24) in the search area:
  - (a) Raster search ordering
  - (b) H.264 JM implementation of spiral search ordering
  - **(c) The proposed rate-constrained search ordering**

0	1	2	3	4
5	6	7	8	9
10	11	12	13	14
15	16	17	18	19
20	21	22	23	24

(a)

23	10	12	14	24
21	7	2	8	22
19	5	0	6	20
17	3	1	4	18
15	9	11	13	16

(b)

22	14	6	15	24
18	10	2	12	17
7	3	0	1	5
19	11	4	9	13
23	16	8	20	21

(c)

** The gray square is the center of each search area, motion vector (0, 0).*

EXPERIMENTAL RESULTS

- SAD reduction using the proposed search ordering compared to the H.264 JM reference software's implementation of spiral search, as a function of block size and QP, for several CIF video sequences.

		Foreman # of SAD operations for 300 frames			Football # of SAD operations for 260 frames			News # of SAD operations for 300 frames		
QP	Size	Spiral	Proposed	Red. %	Spiral	Proposed	Red. %	Spiral	Proposed	Red. %
28	4	416 262 070	388 993 410	**6.55%**	1 115 661 675	1 035 142 134	**7.22%**	134 537 882	128 099 468	**4.79%**
28	8	785 227 992	765 544 865	**2.51%**	1 955 919 279	1 882 526 019	**3.75%**	290 136 328	286 173 266	**1.37%**
28	16	409 325 310	401 608 855	**1.89%**	903 904 793	879 156 973	**2.74%**	309 741 039	308 103 709	**0.53%**
32	4	225 442 778	204 861 411	**9.13%**	698 105 494	638 767 242	**8.50%**	81 710 975	76 734 942	**6.09%**
32	8	648 570 481	627 984 818	**3.17%**	1 659 309 376	1 594 498 115	**3.91%**	255 001 256	249 897 228	**2.00%**
32	16	422 019 606	414 160 704	**1.86%**	922 208 528	898 298 829	**2.59%**	291 083 798	289 592 570	**0.51%**
36	4	107 804 660	95 285 467	**11.61%**	393 409 060	353 080 194	**10.25%**	44 836 321	41 544 099	**7.34%**
36	8	529 033 021	507 752 081	**4.02%**	1 185 610 980	1 133 690 522	**4.38%**	215 288 507	212 294 102	**1.39%**
36	16	426 912 515	419 050 593	**1.84%**	923 795 311	900 217 448	**2.55%**	270 475 527	269 005 875	**0.54%**
40	4	47 435 348	41 836 990	**11.80%**	183 815 418	161 532 698	**12.12%**	24 308 026	22 453 474	**7.63%**
40	8	405 457 244	383 738 455	**5.36%**	760 172 034	712 290 223	**6.30%**	166 808 837	163 627 932	**1.91%**
40	16	421 173 116	413 071 553	**1.92%**	876 436 298	856 138 643	**2.32%**	264 566 993	263 016 343	**0.59%**
		Average SAD reduction		**5.14%**	Average SAD reduction		**5.55%**	Average SAD reduction		**2.89%**

Sequence	# Fr.	SAD Red.	Δ Bits (kb/s)	Δ PSNR-Y
Foreman	300	5.14%	-0.18	0.0000
Flower	250	1.61%	-0.21	-0.0017
Football	260	5.55%	0.09	-0.0025
Mobile	300	0.80%	-0.18	0.0008
News	300	2.89%	-0.04	0.0017
Tempete	260	1.14%	-0.11	0.0008
Average		2.86%	-0.10	-0.0001

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CONCLUSIONS

- A new RD-based search ordering was proposed, leading to an average reduction of **2.86%, 5% (for unpredictable motion)** and **10% (for smaller block partitions)** in the number of SAD operations required for motion estimation.
- Changing the candidate block ordering requires **few implementation considerations**, and the **impact on bit rate and visual quality is negligible**.

ÉTS
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