Federal University of Pelotas
Group of Architectures and Integrated Circuits

Hardware-Friendly Motion Estimation Algorithms and its Architectures for High Definition Videos

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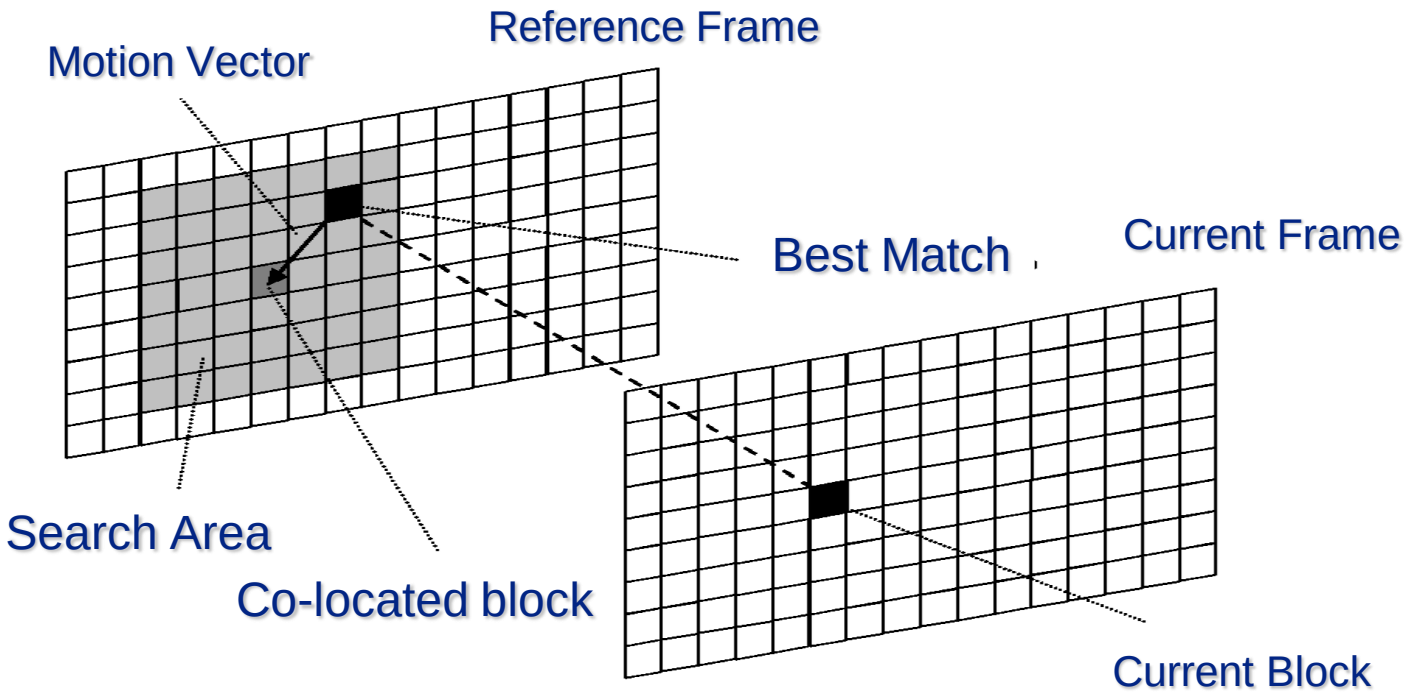
Support:

Motion Estimation

- Uses a similarity criterion
- SAD: Sum of Absolute Differences

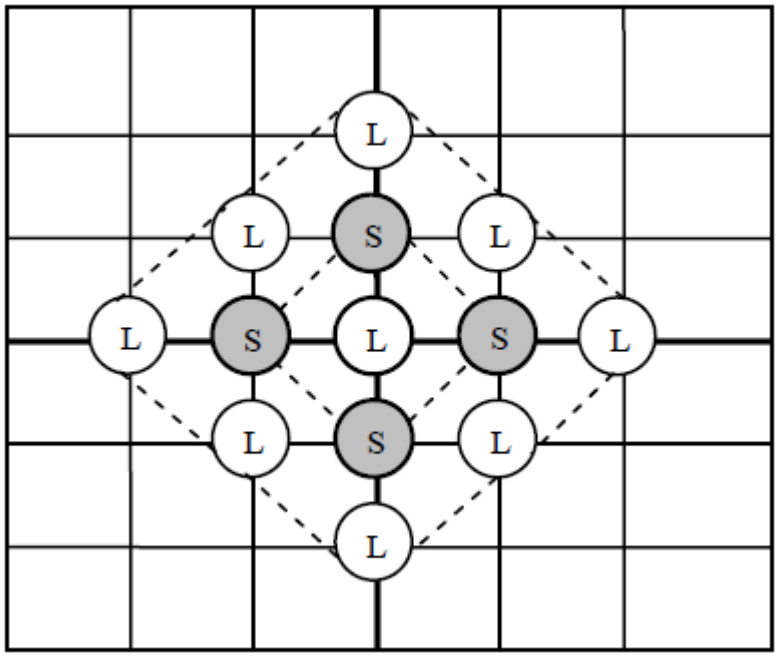


Motion Estimation

- Represents 80% of the encoder complexity
- Responsible for achieving high compression ratios
- Encoders does not restrict how the ME is done
- Explore new solutions:
  - High quality video
  - High compression rates
  - Low computational complexity

Diamond Search Algorithm

- Fast Algorithm
  - Reduce computational complexity compared to Full Search (FS) and mantains good quality results
- Uses two patterns
  - LDSP, to perform the search
  - SDSP, to perform the refinement



Hardware-Friendly ME Algorithms

- Objectives
  - High Quality when encoding HD videos
  - Hardware-Friendly Algorithm
- Two techniques are used
  - Multipoint
    - Dynamic Multi-Point Diamond Search (DMPDS)
    - Low Density and Iterative Search (LD&IS)
  - Random
    - Spread and Iterative Search (S&IS)

DMPDS

- The search area is divided into four sectors
  - In the center position and in every sector of the search area is assigned a DS
- Uses the parameter d, dynamically controlled
  - Small values for low motion videos
  - Higher values for high motion videos
- Self-adaptive according to the video characteristics

- Low Density Multipoint Search
  - Fixes 100 points (25 in each quadrant)
    - 5, 10, 20, 30 e 40 pixels away from the center to each side, in both x and y axis
    - Computes the SAD for each of these points
    - Compares the SADs and select the lowest SAD result
- Central iterative evaluation
  - Performs a DS in the central block of the search area

S&IS

- Random step
  - The search area is divided into four sectors
    - Spread N candidate blocks (N/4 by sector)
    - Compute the SAD for each position
    - Compare the SADs and select the lowest
- Central iterative search
  - Performs a DS in the central block of the search area

Software Results

	DS		FS		**DMPDS**		S&IS		LD&IS	
Video	PSNR (dB)	#ECB ($x10^9$)	PSNR (dB)	#ECB ($x10^9$)	PSNR (dB)	#ECB ($x10^9$)	PSNR (dB)	#ECB ($x10^9$)	PSNR (dB)	#ECB ($x10^9$)
blue_sky	30.01	0.04	34.43	14.66	33.73	0.24	31.12	0.20	31.74	0.20
man_in_car	37.80	0.03	39.99	14.66	39.60	0.24	39.31	0.18	39.26	0.19
pedestrian_area	32.22	0.05	35.97	14.66	35.25	0.34	34.83	0.19	34.79	0.20
Riverbed	24.42	0.06	27.72	14.66	26.86	0.36	26.47	0.21	26.50	0.21
rolling_tomatoes	37.38	0.03	38.18	14.66	38.32	0.28	37.87	0.18	37.87	0.19
rush_hour	36.48	0.03	37.40	14.66	37.28	0.36	36.99	0.18	36.95	0.19
station2	37.76	0.04	38.64	14.66	38.50	0.22	37.98	0.19	38.03	0.19
Sunflower	37.11	0.05	39.00	14.66	38.53	0.43	37.90	0.19	37.88	0.21
Traffic	24.90	0.07	32.45	14.66	28.81	0.39	28.27	0.21	28.03	0.22
Tractor	29.26	0.06	32.25	14.66	31.85	0.33	30.71	0.21	30.32	0.22
Average	**32.74**	**0.05**	**35.71**	**14.66**	**34.87**	**0.32**	**34.15**	**0.20**	**34.14**	**0.20**

Software Results

- Best Quality Results: DMPDS
  - Best trade-off between quality and computational complexity
- Compared with Full Search (FS)
  - Lost only 0.84 dB of PSNR
  - The computational complexity was 45 times lower
- Reason
  - As mentioned above has a parameter dynamically controlled which adapts according to video characteristics

ME Architecture

- Developed in VHDL
- Synthesized to an FPGA Stratix Altera 4
- Block size: 16x16
- Sub-sampling ratio 4:1
- Limit of iterations of the Diamond Search: 5

Synthesis Results

Architecture	Technology	Frequency (MHz)	Area	Memory (Kbits)	Cycles per Block	HD fps	QFHD fps
DMPDS	Stratix 4	187.58	34.5 KALUTs	46.2	170	136	34
LD&IS	Stratix 4	256.84	18.5 KALUTs	46	174	180	45
S&IS	Stratix 4	210.5	18.5 KALUTs	37	174	149	37.3
S&IS	90nm	169	84.32 KGates	55.9	174	119.9	30

Synthesis Results

- Best match: LD&IS
  - The architecture achieved a better processing rate
  - Using low resources available in hardware
  - Processing up to 45 QFHD frames per second

Conclusion

- Best Algorithm: DMPDS
  - Higher trade-off between video quality and computational complexity
  - Compared to FS:
    - 0.84 dB less PSNR and 45 times less computational complexity
- Best Architecture: LD&IS
  - Best processing rate
  - Lower utilization of hardware resources
  - Able to process up to 45 QFHD frames per second

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Thanks!

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Support:

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